INDIANA HARBOR AND CANAL
CONFINED DISPOSAL FACILITY

GROUNDWATER PROTECTION SYSTEM

APPENDIX B

U.S. Army Corps of Engineers, Chicago District
Geotechnical Branch

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GROUNDWATER PROTECTION SYSTEM

APPENDIX B

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INTRODUCTION

Purpose

1. The purpose of this appendix is to document the analysis, design and recommendations for the groundwater protection system to be installed for the Indiana Harbor Confined Disposal Facility (CDF). Refer to the Main Report for discussion of the various features of this project. The Main Refinery Area of the former Energy Cooperative, Inc. site will be used for the construction of the CDF.

Existing Groundwater Conditions

2. The ECI site is located in East Chicago, Indiana. The topography, soil, and groundwater conditions for the region and for the ECI site are discussed in Appendix C - SUMMARY OF GEOTECHNICAL INVESTIGATIONS. The site was formerly an oil refinery and has a significant amount of contaminates, primarily floating hydrocarbons, present in the groundwater. Some measurement points show as much as 3 to 9 feet of hydrocarbons present on top of the groundwater. A recovery operation has been in-progress on the site for several years to capture the floating contaminates so they do not migrate off the site. As of May 1999, a total of 39,359 gallons of hydrocarbon had been recovered from the product recovery systems operating on the South Tank Farm, West Tank Farm and the Main Refinery Area of the ECI Site since the start of recovery operations. A total of 129 gallons of product were recovered during May 1999.

3. A testing program is performed each quarter by Arcadis Geraghty & Miller, Inc. to sample and analyze the groundwater samples from multiple sampling points around the ECI Site. A table of the test results from the samples collected on November 12, 1998 is included in attachment B-1. The groundwater samples are analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), and methyl-tertiary-butyl-ether (MTBE), total petroleum hydrocarbons (gasoline and diesel range organics), total metals, and other non-metallic and physical parameters. A thorough discussion of the site contamination can be found in Appendix I - HTRW.

CDF Operations

4. The CDF will be constructed to contain contaminated sediments from the Indiana Harbor and Canal. When placed in the CDF these sediments will be saturated as a result of dredging operations and will likely be 50 to 80% water, by volume as discussed in Appendix E - DREDGING AND PLACEMENT PLAN. A portion of this water is likely to percolate downward to the groundwater on site, especially in the earlier phases of filling. As this dredged material water is also contaminated, it must be contained and properly treated before being discharged from the site. The treatment requirements are discussed in Appendix D - EFFLUENT TREATMENT SYSTEM.

Proposed Conceptual Design

5. The conceptual design for protecting the groundwater was presented in the Comprehensive Management Plan for the Indiana Harbor and Canal. This design consists of a groundwater cutoff wall encircling the site and a system to maintain an inward gradient (a minimum of 2 feet) that would prevent groundwater from flowing away from the site. A sketch of this concept is shown in figure B-1, below.

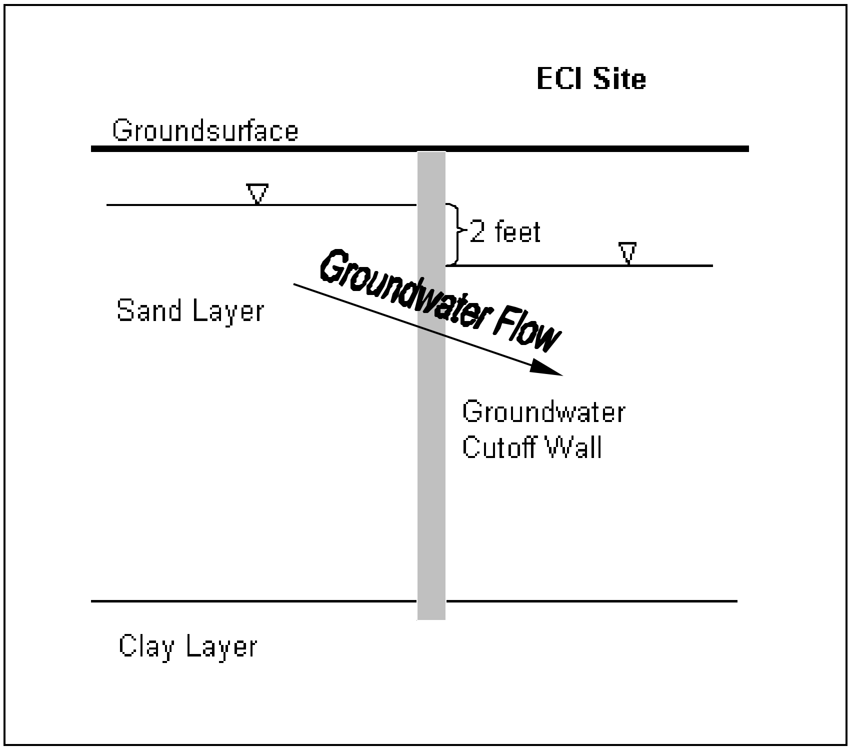

Figure B-1. Conceptual Groundwater Protection Design

6. The cutoff wall is a low-permeability barrier (minimum of $1x10^{-7}$ cm/sec) that will be keyed into a clay layer underlying the site. This barrier will minimize the movement of water either onto or off of the site. An inward gradient means that the groundwater level in the ECI Site will be lowered causing the groundwater to flow towards the site. As a result, contaminants on the site will not be able to migrate away from the site. The water extracted to create the inward gradient will be collected and treated before being safely discharged. A discussion of different alternatives for the groundwater cutoff wall and for the gradient control system is presented below.

CUTOFF WALL ALTERNATIVES

7. The alignment of the cutoff wall of the groundwater cutoff wall will be along the perimeter of the site as close to the property line as possible. This alignment is documented in a design decision included in attachment B-2. The purpose of this alignment is to ensure the entire site has been contained in order to control existing onsite contamination as well as containment of any effluent from the dredged material.

8. The cutoff wall will key into the underlying silty clay a minimum of 3-feet to ensure a complete cutoff. The total depth of wall will be approximately 33 feet. See figure B-2 - ECI Site Generalized Soil Profile and contour plot of the thickness of the silty sand in attachment C-1. The length of the cutoff wall is approximately 10,800 lineal feet divided into four sections: the west (3800 lf), the north (2200 lf), the east (2800 lf) and the south (2000 lf), as shown on plate B-1. The total wall area would be approximately 356,400 sf. Following installation of the cutoff wall, a cap will be placed over the cutoff wall during the required capping of the entire property, as discussed in Appendix A - DIKES, CAP AND CDF LAYOUT.

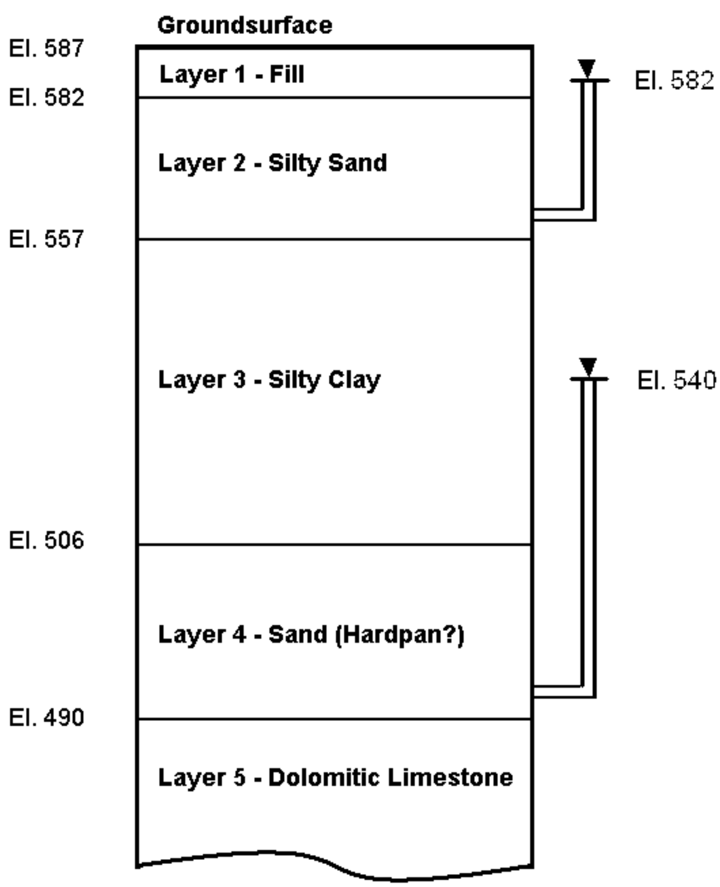

Figure B-2. ECI Site Generalized Soil Profile

9. There are several different construction methods and/or materials that could be utilized to meet the requirement for the groundwater cutoff wall. Three alternatives are discussed below, and are limited to the systems determined to be the most feasible for this application. A description of the cutoff wall method, relative costs, and advantages and disadvantages are included. A summary of the estimated construction costs is also included for comparison purposes. A detailed cost estimate of the best alternative is included in Appendix H - COST ENGINEERING.

Option 1 – Soil-Bentonite Slurry Wall

10. A Soil-Bentonite (SB) Slurry Wall is constructed using a two-step process. The first step is to excavate a trench two-foot wide using a backhoe excavator to the impervious clay layer. Bentonite slurry is placed in the trench to maintain the trench open while the soil-bentonite mixture is prepared. The soil-bentonite mixture is made by mixing a measured amount of dry bentonite powder with soil from the trench excavation. This is typically performed using a bulldozer. When the material has obtained the required consistency, it is placed in the trench displacing the bentonite slurry. The backfilling operation is shown in the schematic in figure B-3, below.

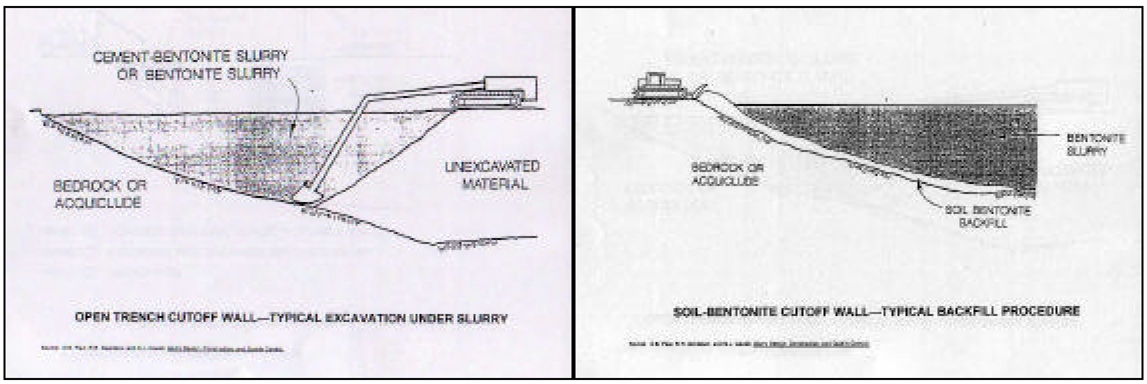

Figure B-3. Schematic of Soil-Bentonite Cutoff Wall Installation

11. The actual mix design would be left to the contractor. The SB mix must have certain chemical (inert to the contaminants noted on site and in the dredged materials) and physical characteristics (hydraulic conductivity less or equal to $1x10^{-7}$ cm/sec). However, bentonite and the on-site contaminants (free-phase hydrocarbons) are potentially incompatible for long duration contact.

12. A significant amount of spoil would remain following SB Wall installation. The material produced would need to be contained on-site within the CDF, as coordinated with the Indiana Department of Environmental Management (refer to attachment B-3). The work crews will require appropriate protection from the on-site contamination, special clothing requirements for those performing mixing operations and possibly respirators for those close to the materials.

Option 2 – Vibrating Beam Cutoff Wall

13. A Vibrating Beam (VB) Cutoff Wall is construction method that utilizes a specialized crane that vibrates a modified H-Beam with injection jets into the ground. Penetration into the silty clay layer is verified by change in the pressure required for penetration. As the beam is withdrawn, the void space created in filled with a slurry product that provides the required permeability and inertness. A schematic of this operation is shown in figure B-4, below.

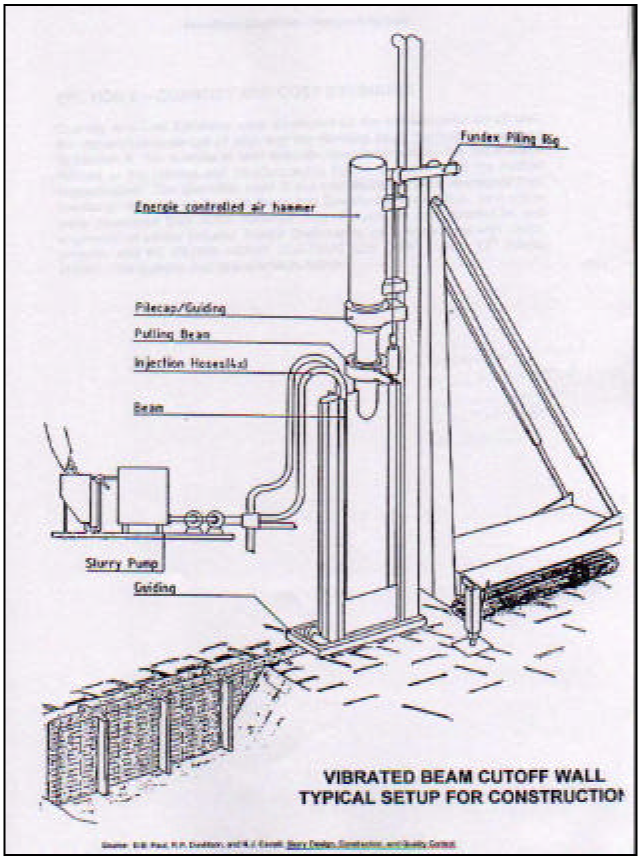

Figure B-4. Schematic of Vibrating Beam Cutoff Wall Installation

14. The material used for injection depends on the requirements for the project. The actual mix design would be left to the contractor. The slurry must be shown to have certain defined chemical (inert to the contaminants noted on site and in the dredged materials) and physical characteristics (hydraulic conductivity less or equal to $1x10^{-7}$ cm/sec).

15. No spoil material is produced from the wall installation other than excess materials from the slurry mixture resulting in very little site cleanup. Also, work crews would experience very little exposure to the on-site contaminants during wall installation. Some disadvantages of this system are that the well is typically only 3-1/2 to 4 inches thick with potential for necking, cavities and windows. As the VB wall is thin, it has a shorter break-thru path than a trench method.

16. The VB method was recently used at an environmental containment project approximately two miles from the ECI Site. The site is the US Lead Plant located in East Chicago, IN. The subsurface conditions are very similar to those at the ECI Site with approximately 30 feet of silty sand underlain by silty clay. This cutoff wall was installed by Slurry Systems, Inc., following approval by the Indiana Department of Environmental Management.

Option 3 – Geosynthetic Cutoff Wall

17. A High-Density PolyEthylene (HDPE) Cutoff Wall is constructed by inserting panels of HDPE to the required depth, see figure B-5. The panels range from 4 to 26 feet wide and are interconnected by a specialized joint welded along the edges of the HDPE panels. These joints would be fabricated in the factory. The HDPE panels are estimated to be 100 mils thick. This method of installation was used at a bulk storage facility in East Chicago, IN in 1991 by Gundle, Inc. As with the VB method, no spoil material is produced from the wall installation other than excess HDPE materials. The work crews would experience very little exposure to the on-site contaminants during wall installation. However, the panels are subject to installation damage creating tears in the membrane and the potential for the interlocks to come apart during installation is a concern.

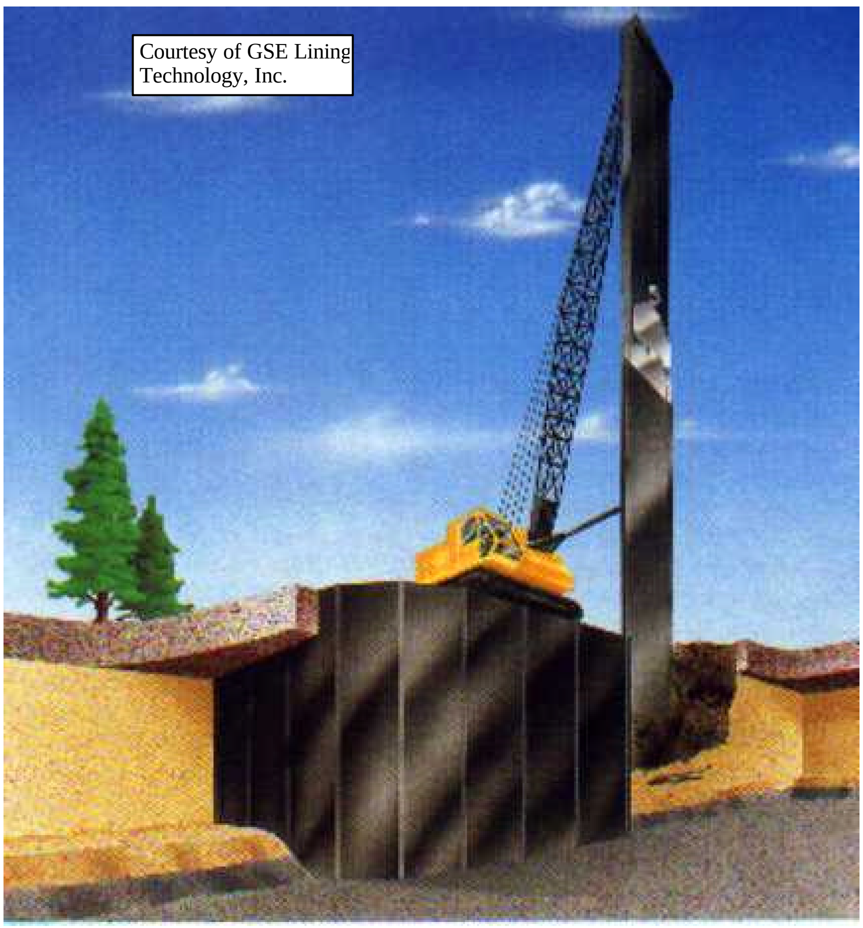

Figure B-5. Schematic of HDPE Cutoff Wall Installation

Recommendation

18. A comparative cost estimate was prepared for the three alternatives considered above, and is included in table B-1, below. A detailed analysis is included in attachment B-4.

Table B-1. Comparative Costs of Groundwater Cutoff Wall Options

Type Cutoff Wall	Soil Bentonite Slurry Wall	Vibrating Beam Cutoff Wall	HDPE Cutoff Wall
Area	356,400 SF	356,400 SF	356,400 SF
Length	10,800 LF	10,800 LF	10,800 LF
Depth	33 Ft.	33 Ft.	15 Ft.
Soil	Sand	Sand	Sand
Mob/Demob	$100,000	$100,000	
Cutoff Wall	$1,480,736	$923,038	
Sub-Total	$1,580,736	$1,023,038	
Markups, 30.76%	$486,234	$314,686	
Sub-Total	$2,066,970	$1,337,724	
Contingency, 20%	$413,394	$267,545	
Total Cost	$2,480,364	$1,605,269	
Unit Price/SF	**$6.96/SF**	**$4.50/SF**	**$13.32/SF**
Cost/LF	$230/LF	$150/LF	

19. The costs are based on the cutoff wall encircling the perimeter of the ECI Site. The costs of the SB and the VB cutoff walls were estimated based on the wall penetrating to the clay layer, averaging 33 feet deep. However, the geosynthetic wall was not constructible without pre-trenching most of the depth. The costs for pre-trenching were not included in the costs for the geosynthetic wall. Even without the pre-trench costs, the geosynthetic wall is considerably higher than the other two alternatives at $13.32 per square foot of wall. Based on the cost analysis in table B-1, the VB Cutoff Wall is the most cost-effective method.

20. It is recommended that the method and materials for construction of the groundwater cutoff wall be left to the construction contractor. Several other alternatives are possible, beyond those considered above. The important factors for the cutoff wall are to create a low-permeability barrier, less than $1x10^{-7}$ cm/sec, and to be chemically inert in the presence of the contaminants at the ECI Site and from the dredged material to be contained at the site. These requirements can be effectively included in the contract specifications, thereby allowing for the widest competition permitting the best possible cost.

INWARD GRADIENT ALTERNATIVES

21. An inward gradient system will be installed around the site to ensure that the local groundwater in the Calumet Aquifer will be drawn towards the ECI Site. This inward gradient will work with the low-permeability barrier and prevent groundwater on the site from migrating into adjacent properties or toward the Lake George Branch of Indiana Harbor. The groundwater within the containment area will be maintained a minimum of two feet below the water levels outside of the property. The volume of groundwater to be handled by the gradient control system will come from the following potential sources:

- Precipitation
- Drainage from the Dredged Material
- Seepage into the site from the Lake George Branch across the southern property boundary
- Groundwater seepage into the site across the western, northern and eastern property boundaries

22. To create the inward gradient, two possible alternatives were evaluated. The first alternative is a french drain, essentially a gravel drain around the perimeter of the site with a pipe to carry the collected water. The second alternative is a series of extraction wells. These wells would pump water out of the sand layer creating a cone of depression in the groundwater around the site perimeter. A more thorough description of these alternatives is discussed below.

French Drain

23. A french drain consists of a trench filled with gravel to collect groundwater. The collected water is then transported via a pipe located in the bottom of the trench. Figure B-6 shows a cross-section of a typical french drain.

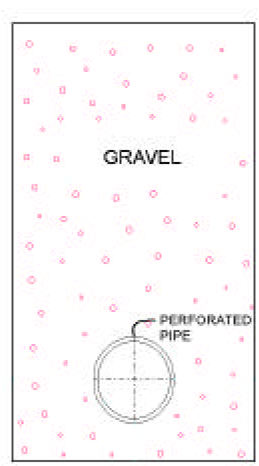

Figure B-6. Typical French Drain

24. Installation of the french drain will require placement below the existing groundwater level on the ECI Site. The bottom of the drain must be a minimum of two feet and more likely three feet below the predicted groundwater level on the exterior side of the cutoff wall. The gravel in the drain would be a clean, free-draining aggregate to allow groundwater to easily flow to the collector pipe. The material would need to follow filter criteria to prevent piping of fines particles from the surrounding sand into the drain. This filter criteria is described in Cedergren (1989) and shown in the following equations:

$$\frac{D_{15}(Filter)}{D_{85}(Soil)} \leq 5\textbf{;} \quad \textbf{Eqn. B-1}$$

$$\frac{D_{15}(Filter)}{D_{15}(Soil)} > 5\textbf{;} \quad \textbf{Eqn. B-2}$$

$$\frac{D_{50}(Filter)}{D_{50}(Soil)} \leq 25\textbf{;} \quad \textbf{Eqn. B-3}$$

25. Equation B-1 is known as the piping ratio. This criteria ensures that the particles of the protected soil does not move into the drain, which would cause piping or internal erosion of the soil. The D_{85} of the sand at the ECI Site is generally greater than 0.15 mm, refer to Appendix C – SUMMARY OF GEOTECHNICAL INVESTIGATIONS. Therefore, the D_{15} of the gravel would need to be less than 0.75 mm.

26. The intent of Equation B-2 is to guarantee sufficient permeability to prevent the buildup of large seepage forces and hydrostatic pressures in the drain. It is considered that if the D_{15} of the filter is at least 5 times the D_{15} of the protected soil, the filter will be approximately 25 times more permeable than the soil. The D_{15} of the sand at the ECI Site is approximately 0.075 mm resulting in the D_{15} of the gravel being greater than 0.375 mm.

27. Equation B-3 is also used to prevent piping of the protected soil. The D_{50} of the sand is approximately 0.10 mm, resulting in the gravel D_{50} being less than 2.5 mm. Therefore, based on the filter criteria in the equations above, the gravel drain could consist of INDOT CA-53 or specially graded material.

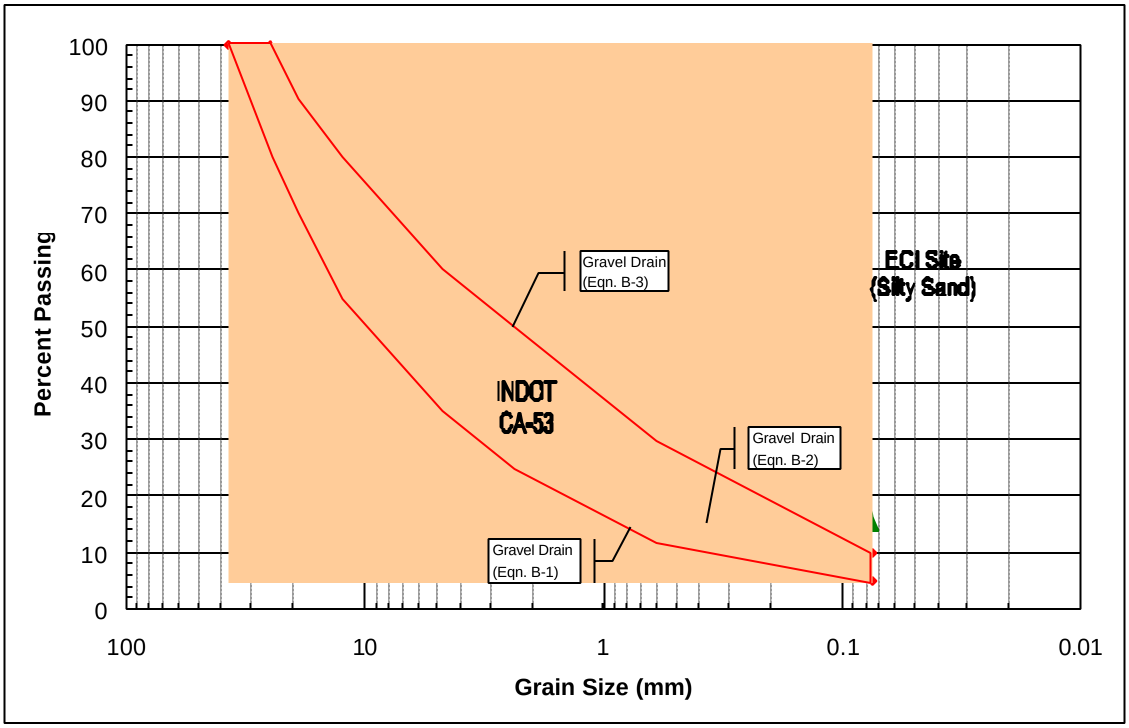

Figure B-7. French Drain Grain Size Distribution

28. The collector pipe would be sized to drain the water flowing into the french drain, thereby maintaining an inward gradient. This pipe would direct the flow towards the on-site treatment facility. Here the collected water would be properly treated before being discharged. The treatment facility is discussed in greater detail in Appendix D – EFFLUENT TREATMENT SYSTEM. As the collector pipe will flow by gravity, the slope on the pipe will need to be a minimum of 0.01 (1-foot drop per 100 feet of length). This will create some difficulty, as the east and west sides of the side are approximately 2800 and 3800 feet, respectively. This will require drops of 30 to 40 feet from the north end of the site to the south. As the topography of the site is relatively flat, lift stations will be necessary at periodic locations (roughly 300 to 500 feet apart) along the perimeter.

Extraction Wells

29. The use of extraction wells to maintain an inward gradient would be similar to the methods used to dewater a construction site. A series of wells would be installed along the perimeter of the site. The wells would pump groundwater into a common header pipe that would carry water to the on-site treatment facility. A schematic of a typical extraction well is shown in figure B-8, below. The wells would interact in order to achieve a minimum two-foot drawdown in-between the wells. The drawdown at the wells would be much greater.

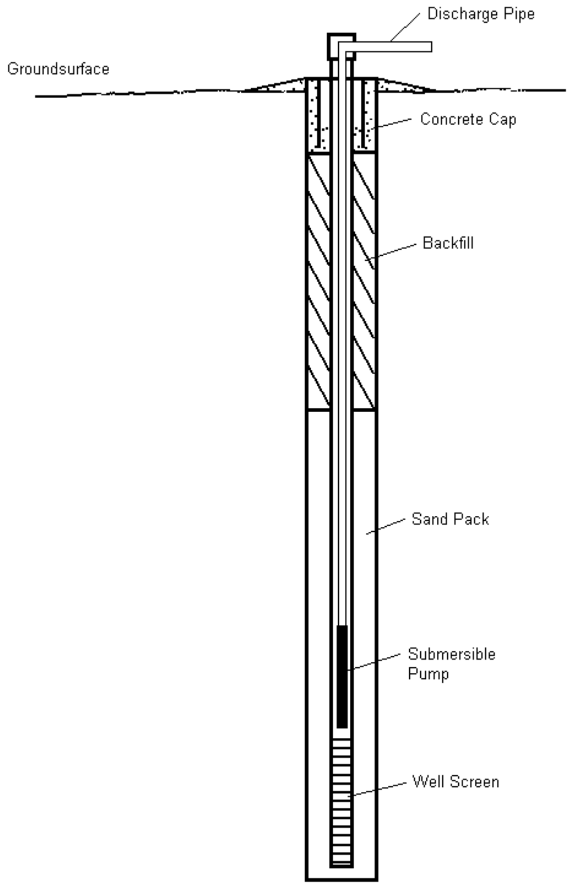

Figure B-8. Typcial Extraction Well

30. A couple of methods are commonly used to lower a water table using wells. A well-point system in which a series of well points are connected to a pump and a deep-well system in which each well has a submersible pump. The advantages of a well-point system are the flexibility and economy. If more drawdown is required in a particular area, additional well-points can easily be added. The effective lift of a well-point system is generally regarded as 15 feet. As the required minimum drawdown is only 2 feet and the water table is generally about 5 to 7 feet below grade, this should be within the operational range of a well-point system. Typical spacings for well-point systems can range from two to over 40 feet, depending on the soil conditions. It is expected that well-points would be needed every 30 feet at the ECI Site, approximately 360 well-points. A disadvantage of the well-point system is that an insulated and heated structure is needed for each pump, as the system must run continuously throughout the year and the potential for freezing of the water must be controlled. Also, the system is somewhat complicated to install and must ensure a vacuum in the entire system. Each well-point will require an automatic value to control flow from the well during pumping.

31.   A deep well system would have a submersible pump in each well. This system may be more expensive than the well-point system but would allow for greater distances between the wells and is a simpler system to install and maintain. Based on the information from the pump tests conducted at the site, well spacing of 100 to 200 feet could be used (refer to figure C-4 in Appendix C – SUMMARY OF GEOTECHNICAL INVESTIGATIONS), resulting in 50 to 100 wells. The primary disadvantage of a deep well system is the costs of having a submersible pump in each well. As these wells are not intended for analytical monitoring of the groundwater, durability and costs are the primary issues. Therefore, PolyVinyl-Chloride (PVC) is recommended as it is typically non-reactive with the hydrocarbons found on the ECI Site and the contaminants likely to be encountered from the dredged materials (Barcelona, et.al., 1983). Stainless steel will be required for items that may come in contact with organic solvents or mechanical parts that cannot be manufactured from PVC.

Recommendation

32. The use of extraction wells is preferred over using a perimeter drain for several reasons. Perhaps the primary reason is the presence of hydrocarbon product floating on top of the groundwater. The thickness of the hydrocarbon layer varies from zero to over 9 feet, see table in attachment C-7. A perimeter french drain would be difficult to install, as it would need to be a minimum of two feet below the top of the corrected water level. In areas with several feet of hydrocarbons this would lead to a deep installation through the contaminated fluid. In addition, the slope for the drain would require the use of a series of lift stations to transport the collected water due to the flat topography of the site. These lift stations would need to handle a mixture of oil and water, making the entire system much more complicated. In addition, the use of a perimeter french drain would not be able to adapt to fluctuation in the groundwater levels on the exterior of the cutoff wall. If groundwater levels dropped for some reason on the outside of the site, the french drain would be unable to maintain an inward gradient.

33. The extraction wells will be screened in the lower portion of the Calumet Aquifer (silty sand) and thereby would only be pumping water. Since the contaminants on site are primarily light non-aqueous phase liquids (LNAPLs), the level of contamination of the groundwater pumped from the extraction wells should be relatively low. This will allow for easier treatment operations which are discussed in Appendix D – EFFLUENT TREATMENT SYSTEMS. Another advantage of the extraction wells is that they are more flexible in drawing down the water levels within the containment area. The pumps can lower the water table below the necessary two feet if desired operationally to handle excess seepage from dewatering the dredged material or additional wells installed in a problem area.

SUMMARY AND CONCLUSIONS

Construction Features

Inspection Trench

34. A surface geophysical investigation was performed in an attempt to located buried utilities and is discussed in Appendix C - SUMMARY OF GEOTECHNICAL INVESTIGATIONS. However, the conclusions indicated that to be confident there would not be any obstructions encountered, an inspection trench is necessary. The inspection trench will be performed prior to the installation of the groundwater cutoff wall in order to uncover live utilities and any undesirable material that will require removal. This inspection trench will minimize potential delays in the installation of the groundwater cutoff wall. Relocation of utilities are discussed in Appendix A - DIKES, CAP AND CDF LAYOUT. The inspection trench will consist of a 1.5-foot wide trench, excavated to a maximum of seven feet deep. Live utilities that are encountered will require relocation. All other obstacles will be removed.

35. After the alignment has been verified as being cleared of utilities and other obstacles, the inspection trenches will be backfilled with suitable material from the excavation. Unsuitable material that would be removed includes but is not limited to stumps, roots, and buried logs, pipes, concrete or other construction debris. All unsuitable material will be disposed of within the limits of the CDF. The backfill to be placed in the trenches will only require a minimum amount of compaction, sufficient to ensure that all voids have been filled. Additional compaction is not considered necessary as the subsequent groundwater cutoff wall will be placed in the same alignment and filled.

Groundwater Cutoff Wall

36. A groundwater cutoff wall is recommended around the perimeter of the ECI Site to control the seepage of groundwater into as well as out of the site. The cutoff wall will work with a gradient control system to prevent contaminants from the ECI Site and the CDF from migrating outward. The cutoff wall will also limit the movement of groundwater onto the site due to the inward gradient created. This will reduce the amount of groundwater that will require treatment and restrict additional contaminants from entering the site from adjacent areas.

37. The cutoff wall must consist fully penetrate the Calumet Aquifer and key into the underlying silty clay layer a minimum of 3-feet. The total depth of the cutoff wall will be approximately 33 feet. The materials and installation of the wall will be the responsibility of the contractor. However, the materials must be proven to be able to create a barrier having permeability less than 1×10^{-7} cm/sec and chemically inert with the contaminants found at the ECI Site and in the dredged materials from the Indiana Harbor.

38. From the comparisons described above, the most cost-effective system appears to be a Vibrating Beam Cutoff Wall. The VB system is a method to install a cutoff wall. The material used for creating the low-permeability barrier is assumed to be Impermix™. Product information is included in attachment B-4.

Gradient Control System

39. The gradient control system will consist of a series of wells that will be pumped to drawdown the groundwater within the groundwater cutoff wall. A minimum gradient of 2 feet is required across the cutoff wall to ensure that contaminants will not migrate away from the site.

40. The well system could consist of well-points or deep wells. Selection of the type of system and optimization will be performed following development of a groundwater model described below. For estimating purposes, a deep well system is considered conservative and is described in the following.

41. The gradient control system would consist of approximately 110 wells spaced approximately 100 feet apart. Each well would be drilled to a depth of about 30-feet and be constructed of 5-inch diameter screen five-feet long and 5-inch diameter PVC casing sufficient to allow approximately 16 to 24 inches to remain above grade. The well screen should be Type 316 Stainless Steel and continuously wire-wrapped with a slot size of 0.010-inches (10 slot). The wells will require a filter pack to prevent piping as the sand material is very fine (D_{30} ~ 0.003-inches) as indicated in the sieve analysis (refer to Appendix C). Each well will contain a 1/2-hp single-phase submersible pump suspended on 1-inch diameter PVC pipe and positioned above the screen at a depth of approximately 20 feet. A check valve would be installed above the pump to prevent backflow. Each pump would be powered by 220-volt electrical service. Each well would also have a pitless adapter to conduct the water from the well to the perimeter header pipe and located below frost depth. Included in the well would be a vibrating wire transducer that would be used to automatically monitor the water level within the well.

42. The water from each well will be pumped to a header pipe that will convey the water to the on-site water treatment facility. The header pipe shall be buried at least four feet below final grade to prevent freezing during winter months. The pipe is estimated to be 12-inch diameter PVC. The size will be optimized after the number and types of wells are determined. The submersible pumps will pressurize the pipe and therefore it will not require a slope to carry water to the treatment facility. Check valves would be placed every 300 to 500 feet to prevent water from moving in the wrong direction.

43. A system of monitoring wells will be located on the exterior side of the cutoff wall to monitor the groundwater levels. These wells will work in conjunction with the extraction wells to ensure that an inward gradient is maintained and be spaced approximately 400 feet apart on the west, north, and east sides of the site (the Canal is along the southside). The monitoring wells will consist of 2-inch diameter PVC pipe with a 5-foot long 2-inch diameter PVC screen. The screen would be positioned about 5 feet above the underlying clay layer, resulting in a well about 30-feet deep. The monitoring wells will contain a vibrating wire transducer that would automatically measure the groundwater level in the well. The wells will also have a steel well protector to prevent damage. Protective bump posts will be installed where necessary in heavy traffic areas.

44. A control panel will be established at the treatment facility to monitor and control the operation of the pumps and record the water levels measured by the transducers in the wells. The water level information will be compared between the monitoring wells and the extraction wells to determine when the pumps will be turned on and off. The required power for the pumps is 140 kVA. The pumps would be divided into 4 to 10 zones. The power supply can be integrated into the system to provide power to the on-site treatment facility. Allowance may be needed to have a backup generator in the event of power outages. The requirements for the backup system would be developed during final design.

Summary of Groundwater Protection System

45. A summary of the construction items and quantities are included in table B-2, below. A detailed cost analysis of these items are included in Appendix H - COST ENGINEERING. The layout of the groundwater control system is shown on plate B-1. Details of the various features are shown on plate B-2.

Table B-2. Summary of Groundwater Protection System

Item No.	Description	Estimated Quantity	Unit of Measure
1	INSPECTION TRENCH		
	Excavation	4,200	CY
	Mob/Demob	1	LS
2	GROUNDWATER CUTOFF WALL		
	Cutoff Wall Installation	356,400	SF
	Mob/Demob	1	LS
3	GRADIENT CONTROL SYSTEM		
	Extraction Wells and Pumps	110	EA
	Monitoring Wells	22	EA
	12-in Dia PVC Pipeline	10,800	LF
	Automated Control System (zones)	10	EA
	140 kVA Substation	1	LS
	Mob/Demob	1	LS

System Operation

Initial Operations – Establish Inward Gradient

46. Following construction of the groundwater cutoff wall and installation of the gradient control system, the extraction pumps will begin to lower the water level a minimum of two-feet within the containment area. The extracted water will be treated by an on-site treatment facility before being discharged, refer to Appendix D - EFFLUENT TREATMENT SYSTEM. Placement of dredged material into the CDF cannot occur until the gradient control system is operational.

47. The volume of water to be extracted to create the inward gradient will be determined following an analysis from the groundwater model recommended below. An initial estimate of this volume is shown below.

$$V = A \bullet t \bullet n \textbf{;} \quad \textbf{Eqn. B-4}$$

where:

V = volume of water to be extracted (cubic feet)

A = area of the site (square feet)

t = drawdown (feet)

n = porosity

***V* = 7,085,000 x 2 x 0.40 = 5,668,000 cf = 42,400,000 gallons**

48. The extraction wells can realistically pump at an average of 15 gpm for a total of 1,650 gpm based on 110 wells. However, the true capability will be determined by the on-site treatment facility that is estimated to be about 100 to 200 gpm. At full pumping capacity, the initial dewatering could be accomplished in approximately 20 days. However, the capacity of the on-site treatment facility would require about 150 days for dewatering. An option to be considered is handling the initial drawdown separately, either with a package treatment plant or discharging to the East Chicago Water Management District. Following the initial drawdown, the extraction wells would only need to operate to maintain the minimum 2-foot drawdown.

CDF Filling Operations

49. When the CDF becomes operational, the dredged material will include a significant amount of water. Some of this water will percolate into the underlying sand of the Calumet Aquifer, especially during the early stages of filling. Refer to Appendix E - DREDGING AND PLACEMENT PLAN for a description of the dredged material handling operations and the amount of water to be removed from the sediments. The water that percolates down into the Calumet Aquifer will tend to rise the groundwater within site. However, the gradient control system should have sufficient capability to remove this water. If the system appears to become overwhelmed, then dredging operations will need to be slowed. This condition will be evaluated in the recommended groundwater model.

Interim Operations

50. In the periods between dredging operations, the gradient control system will continue to operate. The sources of water entering the containment area will come from precipitation and from seepage through the cutoff wall. Precipitation will comprise the most significant portion of the groundwater and will significantly diminish as the CDF is filled. Runoff will likely be collected before entering the groundwater. The volume of seepage through the cutoff wall is estimated by Darcy's equation below.

$$q = kiA\,;\quad \textbf{Eqn. B-5}$$

where:

q = seepage (cubic feet/minute)

k = hydraulic conductivity of the cutoff wall (feet/min)

i = gradient across cutoff wall (feet/feet)

A = area of cutoff wall (square feet)

$$\mathbf{Q = (2.0x10^{-7})\ x\ (2/1)\ x\ (356{,}400) = 0.14\ cfm = 1.0\ gpm}$$

51. This estimated seepage volume is very small. Therefore, the pumps will not need to run very often during the interim period, unless a significant rainfall event percolates into the groundwater. As mentioned in Appendix C (table C-1), the average rainfall in the project area is 40 to 50 inches per year. This situation would also be evaluated in the groundwater model.

Future Analyses

52. Additional analyses are required to properly design the recommended groundwater control system. These analyses would be focused on determining the appropriate spacing and pumping capacity of extraction wells in the gradient control system. As shown above, installation of the groundwater cutoff wall will significantly reduce seepage entering the site. Therefore, to design the gradient control system, a groundwater model is recommended. Development of this model is discussed below.

Groundwater Model

53. The specific model recommended for this project is GMS 2.1. The Department of Defense, in partnership with the Department of Energy, the U.S. Environmental Protection Agency, Cray Research, and 20 academic partners, developed the DoD Groundwater Modeling System (GMS). The GMS provides an integrated and comprehensive computational environment for simulating subsurface flow, contaminant fate/transport, and the efficacy and design of remediation systems.

54. GMS integrates and simplifies the process of groundwater flow and transport modeling by bringing together all of the tools needed to complete a successful study. GMS provides a comprehensive graphical environment for numerical modeling, tools for site characterization, model conceptualization, mesh and grid generation, geostatistics, and sophisticated tools for graphical visualization.

55. Several types of models are supported by GMS. The current version of GMS provides a complete interface for the codes FEMWATER/LEWASTE, MODFLOW, MODPATH, MT3D, RT3D, and SEEP2D. Many other models will be supported in the future, such as UTCHEM, NUFT3D, ParFlow, and ADH.

56. Model Description. MODFLOW will be used as the modeling package in GMS after evaluating the requirements of the Indiana Harbor CDF Project. MODFLOW was selected because of its modular form that will enabled evaluation of groundwater fluctuations caused by varying infiltration rates and pumping rates from the ECI Site. In addition, the geology of the site is rather simple and can be easily modeled. The MODFLOW program is one of the most widely used and tested models available and is well documented.

57. MODFLOW was developed in 1984 by the United States Geological Survey as an expansion to an earlier model created by Trescott (1975). The model is written in FORTRAN computer language as a primary program that works with a number of modular subroutines. The subroutines solve independent computations for various physical problems encountered in hydrogeologic systems and account for mass transfers between sources and sinks. Each of the subroutines can be called as needed, allowing the modeler to customize the model to fit project site conditions.

58. MODFLOW is accepted throughout the country as an industry standard and through repeated use has demonstrated utility and flexibility. However, a major drawback with the usage of MODFLOW is that unsaturated flow cannot be taken into account. This type of flow will occur from rainfall precipitation and from dewatering of the dredged material. This flow will be handled as recharge to an unconfined aquifer.

59. Steady-State Analysis. MODFLOW is a finite difference numerical groundwater model that solves a system of simultaneous equations for potentiometric head in the aquifer. The simultaneous equations are algebraic solutions to the partial differential equation that describes the movement of water through a saturated porous media:

$$\frac{\partial\left(k_{xx}\,\partial h/\partial x\right)}{\partial x}+\frac{\partial\left(k_{yy}\,\partial h/\partial y\right)}{\partial y}+\frac{\partial\left(k_{zz}\,\partial h/\partial z\right)}{\partial z}-W=0\,; \qquad \textbf{Eqn. B-6}$$

where;

k_{xx}, k_{yy}, k_{zz} = hydraulic conductivity in the x, y, and z directions (which are oriented parallel to the maximum, minimum and intermediate values).

∂h = change in head

$\partial x, \partial y, \partial z$ = partial derivative with respect to the x, y, and z directions.

W = volume contributed or lost to a source or sink

60. This is the equation for steady state flow of water through a porous saturated media. The fundamental basis for the equation is conservation of mass. The differential equation can be approximated with a series of algebraic expressions that can be simultaneously solved for head. After the system of simultaneous equations has been solved and the simulation is complete, a subroutine computes the mass transfer into and out of each cell of the model. The total mass balance at the end of the simulation should be near 0 for the solution to be correct. In addition to this, all input parameters used in the model must fall within the range of values as determined from field tests.

61. Flow into or out of an aquifer due to external sources such as; wells, drains, rivers, rainfall, etc., are expressed in the W term of Equation B-6. It is the W term that allows for evaluation of the groundwater control system alternatives.

62. <u>Transient Analysis</u>. Transient simulations indicate how head fluctuates as a function of time. Transient analysis are needed to refine the pumping needed from the extraction wells to determine how much water and how long the pumping will be needed. This information will be used to determine the final recommended well spacing for the extraction wells. The transient equations take into effect the gain or loss in storage due to the raising or lowering of heads as a function of time. The equation is:

$$\frac{\partial\left(k_{xx}\,\partial h/\partial x\right)}{\partial x}+\frac{\partial\left(k_{yy}\,\partial h/\partial y\right)}{\partial y}+\frac{\partial\left(k_{zz}\,\partial h/\partial z\right)}{\partial z}-W=S_s\left(\partial h/\partial t\right); \qquad \textbf{Eqn. B-7}$$

where;

k_{xx}, k_{yy}, k_{zz} = hydraulic conductivity in the x, y, and z directions (which are oriented parallel to the maximum, minimum and intermediate values).

∂h = change in head

$\partial x, \partial y, \partial z$ = partial derivative with respect to the x, y, and z directions.

W = volume contributed or lost to a source or sink

S_S = storage coefficient

∂t = change in time

63. This is similar to Equation B-6, only the right side of the equation includes the term that represents the loss or gain of water due to the change in storage as a function of time and change in head.

64. Model Limitations. The MODFLOW model generates one head value for each cell. The accuracy of the model is therefore limited by cell spacing. The model for this project has not yet been developed, however the size of the cell will be made as small as practical around the ECI Site. The size of a cell will not exceed 1.5 times the size of the cell adjacent in order to minimize scale effects and distortions. A second limitation of the model is that during calibration, accurate piezometric maps must be available. The water levels readings from the existing piezometers on the ECI Site will provide the necessary data. However, data outside of the site is very limited. However, the proposed model may not require this information as discussed below.

Input Parameters

65. A number of aquifer characteristics are required for the groundwater model. Proper conceptualization of the physical system is very important in the creation of an accurate model. Natural hydrologic boundaries such as rivers and lakes, aquifer hydrostratigraphy and characteristics (ie. thickness, storativity and conductivities of the various layers that makeup the model), leakage between aquifers, stream/aquifer interaction, well pumpage, evapotranspiration and recharge are all required for the area.

66. Geologic Layers. The geologic layers to be used in the groundwater model are shown in figure B-9, below. Essentially, the model will consist of three layers, the existing and planned fill (Layer 1), the Calumet Aquifer (Layer 2), and the underlying silty clay (Layer 3). Layer 1 may be divided into two layers to account for the seepage through and from the dredged material. These layers are described in Appendix C - SUMMARY OF GEOTECHNICAL INVESTIGATIONS.

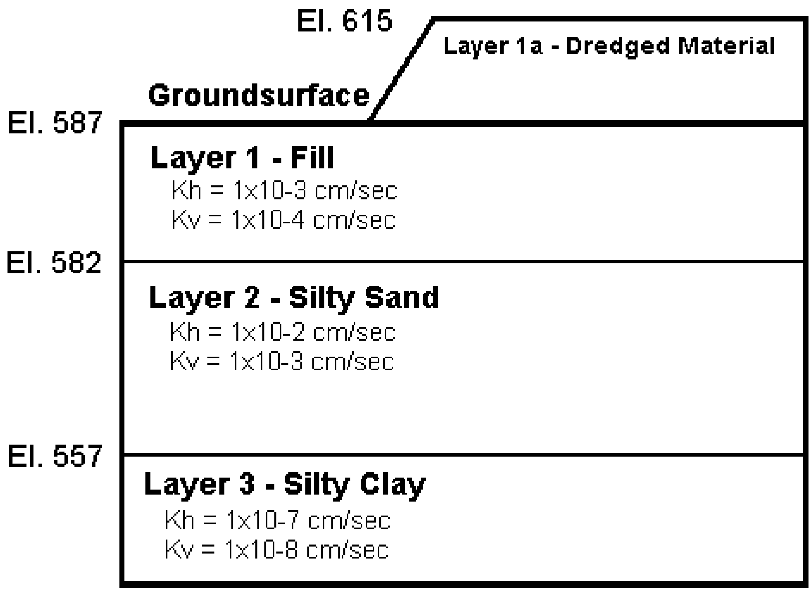

Figure B-9. Model Layers

67. Boundary Conditions. Boundary conditions are constraints imposed on the model grid that express the nature of the physical boundaries being modeled. Boundary conditions greatly influence the computation of flow velocities and head within the modeled area. Three types of boundary conditions are commonly used: 1) specified head; 2) specified flux or flow; and 3) value-dependent flux or head dependent flow.

68. A specified head boundary, also known as Dirichlet condition, is used when a water elevation is known and is not likely to change, such as a lake or reservoir or other known water surface. This type of boundary is proposed for the perimeter of the ECI Site. It is assumed that the water levels outside of the cutoff wall will remain at the elevations noted from the water level data. Some fluctuation in this levels will not affect the results from the model, as the pumping will be based on maintaining a minimum of two-foot drawdown across the cutoff wall.

69. A specified flux or flow boundary, also known as a Neumann condition, is used when the amount of flow into and out of the boundary is known. The most common specified flux boundary is the 'no-flow' boundary. This boundary is used when a groundwater divide is known or a significant difference is hydraulic conductivity can be determined, such as a sand-clay interface. Caution if needed when using a groundwater divide as a 'no-flow' boundary as this divide can move depending on the stresses imposed on the groundwater system. It is not anticipated that this type of boundary condition will be used in the groundwater model for the ECI Site.

70. A value-dependent or head dependent flow boundary, also known as a Cauchy condition, controls the flow through the boundary according to some external constraint. Examples include infiltration from a pond dependent on pond levels, and injection of well water dependent upon injection pressure. This type of boundary is used commonly in transient simulations. The cells containing extraction wells will be head dependent.

71. Model Grid. The model area will be divided into discrete cells (discretization) by creation of a grid of varying dimensions. Cell sizes will be approximately the same size as the zone of concern is near the edge of the model grid. Each cell will characterize the physical conditions found at that location, based on the parameters assigned to the cell. The output from the groundwater model will indicate the water level in the cell as well as the flow of water into and out of the cell. Cell sizes of 10-feet could be used in the model. A grid with cells of this size would be about 250 x 400. The model grid would be setup parallel and perpendicular with the primary axis of the ECI Site. This orientation also alignments with the Lake George Branch of the Indiana Harbor.

72. Recharge. Recharge is applied to the top layer of a groundwater model. This value accounts for the water entering the system from precipitation. An on-site weather station is not available. The closest known weather station is at Valparairso, IN. The average precipitation, evaporation, and temperature are shown in table C-1. Due to the proximity of Lake Michigan, the local weather is somewhat different than Valparaiso, especially precipitation. Average annual precipitation at the ECI Site may be up to 50 inches per year. The Illinois State Water Survey Cooperative Groundwater Report 1-5 indicates that 10 to 12% of the annual precipitation recharges the groundwater. Hence the mean annual recharge to the Calumet Aquifer would be:

$$R = (0.11)(50\ ^{\text{inches}}/_{\text{year}})(^{1\text{ ft}}/_{12\text{ inches}})(^{1\text{ year}}/_{365\text{ days}}) = 1.26 \times 10^{-3}\text{ ft/day}$$

73. Geraghty & Miller (1992) developed a groundwater model to design a groundwater remediation program to recover the hydrocarbons floating on top of the groundwater. In this model, they estimated recharge to be approximately 19 inches per year. This recharge will only apply to the site before the perimeter RCRA cap is constructed and before dredged material placement begins, as these materials will greatly reduce the amount of recharge into the groundwater. The groundwater model developed for the CDF project will vary the recharge rate from 5.5 to 20 inches per year (1.26×10^{-3} to 4.57×10^{-3} ft/day), being reduced to zero.

74. Hydraulic Conductivities. The hydraulic conductivity of the various layers has been determined from local field tests and published reports. Pumping tests and field permeability tests performed in wells constructed around the ECI Site. The results from these investigations are shown in tables C-2 and C-3 in Appendix C - SUMMARY OF GEOTECHNICAL INVESTIGATIONS and indicate the hydraulic conductivity of the Calumet Aquifer (Layer 2). The tests indicate permeability ranging from $8.4\text{x}10^{-4}$ to $1.7\text{x}10^{-2}$ cm/sec with an average of $1.3\text{x}10^{-2}$ cm/sec. Vertical permeability is typically between 10 to 30 times less than horizontal permeability (Freeze & Cheery, 1979). For the proposed groundwater model, a consistent ratio of 1:10 will be used. Geraghty & Miller (1992) estimated the hydraulic conductivity for Calumet Aquifer to be 32 ft/day ($1.1\text{x}10^{-2}$ cm/sec) for the groundwater model developed for the remediation program.

75. The hydraulic conductivity of the silty clay underlying the site (Layer 3) was determined from laboratory tests conducted on samples collected during the field investigations. The results indicate hydraulic conductivities ranging from 1.1 x 10^{-8} to 1.9 x 10^{-7} cm/sec. Flow through Layer 3 will primarily be vertical. Therefore, assuming a vertical to horizontal anisotropy of 1:10, the vertical flow or leakance will be about $1x10^{-8}$ cm/sec.

76. Layer 1, the fill material on-site and the dredged material, is separated from the groundwater by an unsaturated zone. The fill material on-site was not tested for permeability. As is appears to be primarily sand, it is assumed to have a horizontal hydraulic conductivity of $1x10^{-3}$ cm/sec. The dredged materials will be primarily fine sediments. The hydraulic conductivity of this material will change over time. Initially, it will have a very high water content and may allow water to flow readily. However, the material will consolidate and its water content will decrease. As this happens, the voids in the sediments will become smaller and less interconnected resulting in a decrease in the hydraulic conductivity. This is discussed in detail in Appendix E - DREDGING AND PLACEMENT PLAN. The material is generally silt sized and will consolidate to about 76.4 pcf at 20% moisture content. From the consolidation test data, an estimate of the hydraulic conductivity of this material can be obtained from the equation shown below (Holtz & Kovacs, 1981).

$$k = \frac{c_v r_w g a_v}{1 + e_o}\textbf{;} \quad \textbf{Eqn. B-8}$$

where:

k = hydraulic conductivity (cm/sec)
c_v = coefficient of consolidation (cm^2/sec)
$?_w$ = density of water (g/cm^3)
g = acceleration of gravity (cm/sec^2)
a_v = coefficient of compressibility (cm sec^2/g)
e_o = initial void ratio

$$\boldsymbol{k = (8.4x10^{-4})(1)(981)(0.0029)/(1+3.231) = 5.7 \text{ x } 10^{-4} \text{ cm/sec}}$$

77. <u>Storativities</u>. The Calumet Aquifer is an unconfined aquifer. Therefore, when water is removed from the aquifer, portions of the aquifer that were previously saturated will become unsaturated. From the pump test information in Appendix C, the storage coefficients for the individual wells ranged from 0.003 to 0.044 and was 0.10 ft^{-1} when the maximum drawdown in all of the wells were plotted versus log distance. Storativity of unconfined aquifers typically ranges from 0.02 to 0.30 ft^{-1} (Fetter, 1994). The values for the individual wells are generally smaller than expected. This variation may be due to value being computed using data from the beginning of the test whereas the overall test value was computed from the total drawdown. For the groundwater model, as storativity of 0.10 ft^{-1} will be used.

78. Water Levels and Well Pumpage. Existing wells are located on the ECI Site. Some of these wells are being used for the site remediation that is currently in-progress. In addition, a trench is being used to siphon off the hydrocarbons floating on top of the groundwater. These facilities are affecting the current groundwater levels. Groundwater levels on the site for 1991 and 1995 are shown on figure C-8. Quarterly reports of groundwater and floating hydrocarbon levels are collected as part of the on-going site remediation. The most recent groundwater information will be used for the development of the groundwater model. The wells and siphon trench will be decommissioned when the site is prepared for the CDF. As a result, these facilities will no longer influence future groundwater levels.

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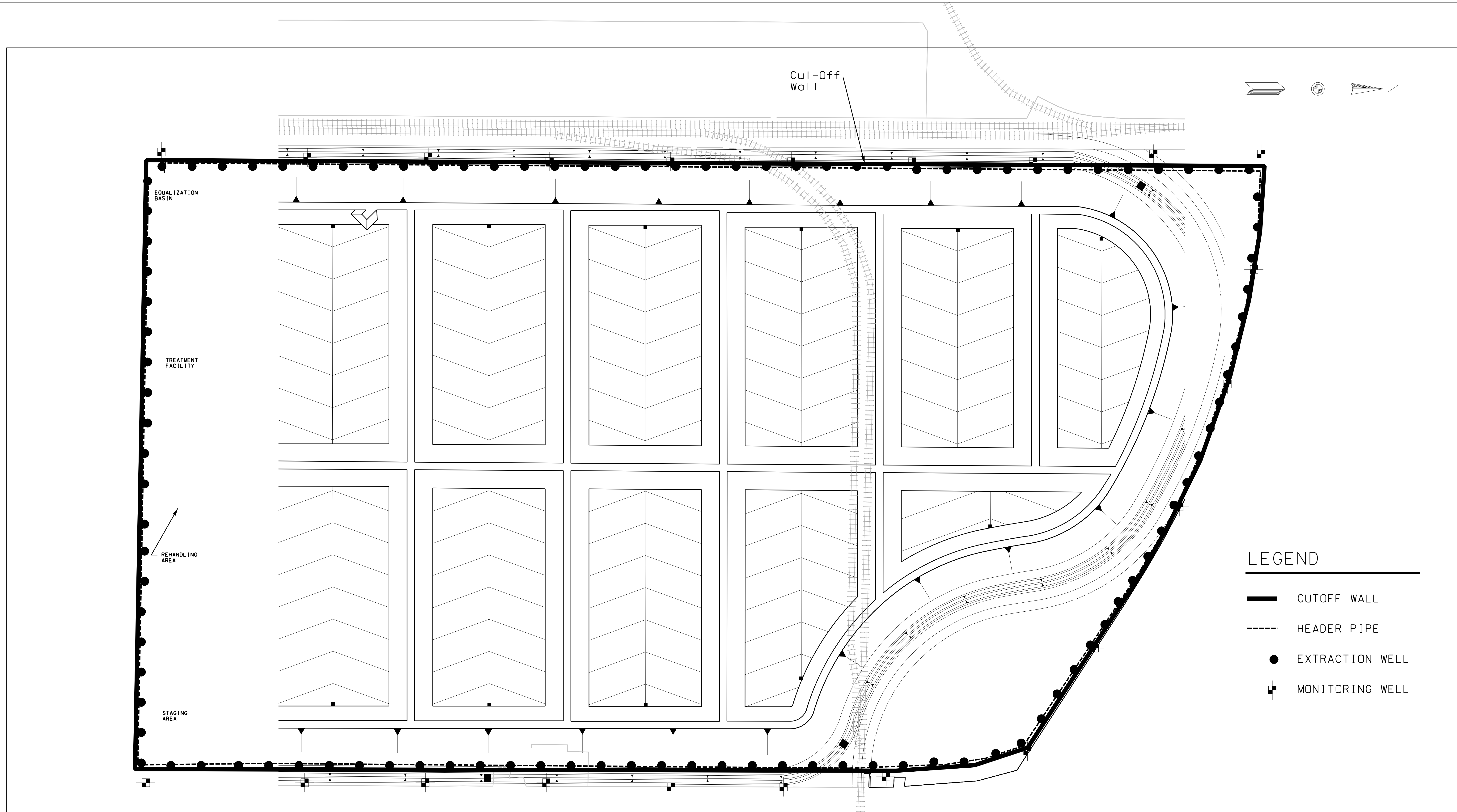
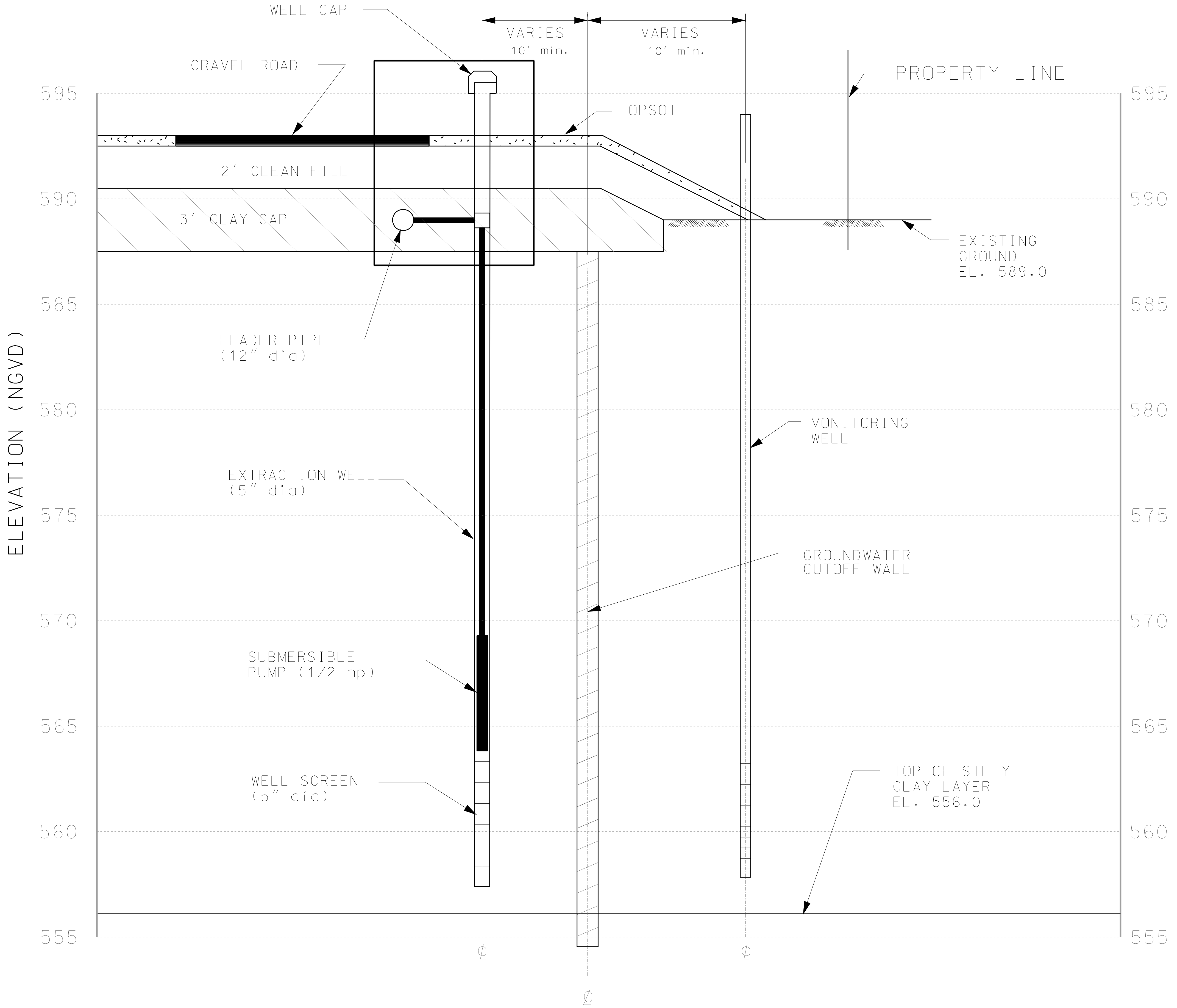


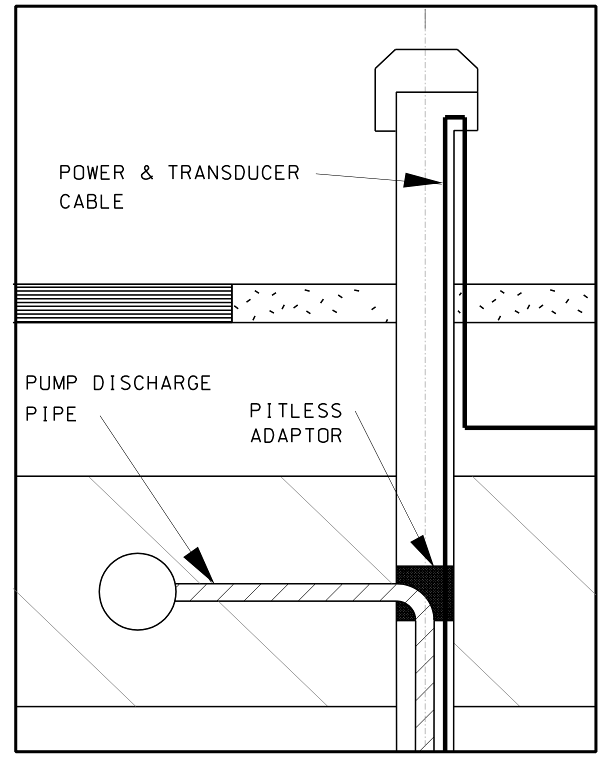
INDIANA HARBOR AND CANAL
EAST CHICAGO, INDIANA
DESIGN DOCUMENTATION REPORT

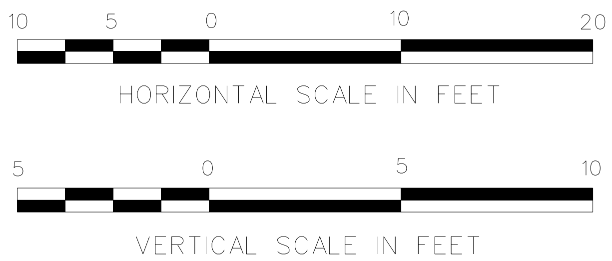
GROUNDWATER PROTECTION PLAN

Scale	Date	Drawing
AS SHOWN	JANUARY 2000	IHCAPB01.DGN

PLATE B-1







INDIANA HARBOR AND CANAL
EAST CHICAGO, INDIANA
DESIGN DOCUMENTATION REPORT

GROUNDWATER PROTECTION DETAILS

Scale	Date	Drawing
AS SHOWN	JANUARY 2000	IHCAPB02.DGN

PLATE B-2

Attachment B-1. Quarterly Groundwater Sampling and Analysis (December 1998)

Table 1. Summary of Groundwater Analytical Results for Samples Collected on November 12, 1998 at the ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	RW-1 11/12/98	RW-1 Duplicate 11/12/98	RW-2 11/12/98	System Effluent 11/12/98	Method Blank 11/12/98	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
TOTAL METALS (mg/l)						
Arsenic	0.006	0.007	ND (0.005)	ND (0.005)	ND (0.005)	0.05
Calcium	160	180	210	190	ND (0.5)	--
Iron	10	9.8	21	2.9	ND (0.10)	--
Lead	ND (0.002)	ND (0.002)	0.004	ND (0.002)	ND (0.002)	--
Magnesium	33	37	40	38	ND (0.5)	
Manganese	0.58	0.61	0.51	0.53	ND (0.03)	--
Sodium	28	31	29	29	ND (0.5)	
VOLATILE ORGANIC COMPOUNDS (µg/l)						
Benzene	130	120	25	ND (1.0)	ND (1.0)	5
Ethylbenzene	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	700
Toluene	3	3	1	ND (1.0)	ND (1.0)	1,000
Total Xylenes	ND (3.0)	ND (3.0)	ND (3.0)	ND (3.0)	ND(3.0)	10,000
Methyl-Tertiary-Butyl Ether	110	110	39	54	ND (1.0)	--
TOTAL PETROLEUM HYDROCARBONS (µg/l)						
Gasoline Range Organics	320	270	ND (200)	ND (200)	ND (200)	--
Diesel Range Organics	2,000	2,600	4,100	1,400	ND (100)	--

mg/l — Milligrams per liter or parts per million (ppm).
µg/l — Micrograms per liter or parts per billion (ppb).
ND — Analyte was not detected at a concentration equal to or greater than the reporting limit ( ).
NA — Indicates the sample was not analyzed for this parameter.
[box] — Indicates the concentration has exceeded the Federal Maximum Contaminant Level.

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Table 1. Summary of Groundwater Analytical Results for Samples Collected on November 12, 1998 at the ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	RW-1 11/12/98	RW-1 Duplicate 11/12/98	RW-2 11/12/98	System Effluent 11/12/98	Method Blank 11/12/98	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
NON-METALLIC (mg/l)						
Total Alkalinity	610	600	680	620	ND (5)	
Bicarbonate	610	600	680	620	ND (5)	
Carbonate	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	
Carbon Dioxide, Free as CaCO3	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	
Hydroxide as CaCO3	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	ND (0.5)	
Sulfate	ND (0.2)	ND (0.2)	1.3	0.9	ND (0.2)	
PHYSICAL PROPERTIES						
pH (Units)	7.00	7.05	7.14	7.27	NA	
Specific Conductance (µS/cm)	1,230	1,220	1,300	1,290	ND (2.0)	
Hardness (mg/l)	540	600	690	640	ND (5)	
Total Dissolved Solids (mg/l)	770	790	790	800	ND (10)	
Total Suspended Solids (mg/l)	19	17	360	10	ND (5)	

mg/l Milligrams per liter or parts per million (ppm).
µg/l Micrograms per liter or parts per billion (ppb).
µS/cm Microsiemens per centimeter.
NA Indicates the sample was not analyzed for this parameter.
< Indicates the concentration is below the detection limit; the detection limit is shown following the < symbol.
$\boxed{}$ Indicates the concentration has exceeded the Federal Maximum Contaminant Level.

Parameters	System Effluent 3/19/93	6/24/93	10/28/93	12/21/93	4/6/94	Duplicate 4/6/94	6/22/94	Duplicate 6/22/94	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
TOTAL METALS (mg/l)									
Arsenic	0.009	0.007	<0.005	<0.005	0.008	0.008	0.007	0.007	0.05
Calcium	230	230	250	250	230	240	240	240	--
Iron	9.8	8.0	4.9	6.1	9.0	9.5	6.9	7.4	--
Lead	<0.003	0.008	<0.003	<0.003	<0.003	<0.006	<0.003	<0.003	--
Magnesium	44	50	60	55	49	50	50	50	--
Manganese	0.80	50	0.69	0.72	0.80	0.82	0.78	0.78	--
Sodium	30	36	41	34	34	36	32	32	--
VOLATILE ORGANIC COMPOUNDS (µg/l)									
Acetone	<10	NA	NA	14	NA	NA	NA	NA	--
Acrolein	<100	NA	NA	<100	NA	NA	NA	NA	--
Acrylonitrile	<100	NA	NA	<100	NA	NA	NA	NA	--
Benzene	140	<1	69	90	140	150	75	78	5
Bromodichloromethane	<1	<1	NA	<1	NA	NA	NA	NA	--
Bromoform	<2	<2	NA	<2	NA	NA	NA	NA	--
Bromomethane	<1	<2	NA	<1	NA	NA	NA	NA	--
2-Butanone (MEK)	<3	NA	NA	<3	NA	NA	NA	NA	--
Carbon Disulfide	<1	NA	NA	<1	NA	NA	NA	NA	--
Carbon Tetrachloride	<2	<1	NA	<2	NA	NA	NA	NA	5
Chlorobenzene	<1	<1	NA	<1	NA	NA	NA	NA	--
Chloroethane	<1	<5	NA	<1	NA	NA	NA	NA	--
2-Chloroethyl Vinyl Ether	<5	<5	NA	<5	NA	NA	NA	NA	--
Chloroform	<2	<2	NA	<2	NA	NA	NA	NA	--
Chloromethane	<2	<5	NA	<2	NA	NA	NA	NA	--
Chlorodibromomethane	<5	NA	NA	<5	NA	NA	NA	NA	--
Dibromomethane	<5	NA	NA	<5	NA	NA	NA	NA	--
Dichlorodifluoromethane	<5	<5	NA	<5	NA	NA	NA	NA	--
1,1-Dichloroethane	<1	<1	NA	<1	NA	NA	NA	NA	--
1,2-Dichloroethane	<2	<1	NA	<2	NA	NA	NA	NA	5

BI-3

Footnotes on Page 3.

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Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	System Effluent 3/19/93	6/24/93	10/28/93	12/21/93	4/6/94	Duplicate 4/6/94	6/22/94	Duplicate 6/22/94	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
VOLATILE ORGANIC COMPOUNDS (continued)									
1,1-Dichloroethene	<1	<1	NA	<1	NA	NA	NA	NA	7
Total 1,2-Dichloroethylene	<5	<1	NA	<5	NA	NA	NA	NA	--
1,2-Dichloropropane	<2	<1	NA	<2	NA	NA	NA	NA	5
Cis-1,3-Dichloropropene	<1	<1	NA	<1	NA	NA	NA	NA	--
Trans-1,3-Dichloropropene	<1	<1	NA	<1	NA	NA	NA	NA	--
1,4-Dichloro-2-Butene	<5	NA	NA	<5	NA	NA	NA	NA	--
Ethanol	<50	NA	NA	NA	NA	NA	NA	NA	--
Ethylbenzene	6	<1	2	1	2	2	3	3	700
Ethyl Methacrylate	<5	NA	NA	<5	NA	NA	NA	NA	--
2-Hexanone	<3	NA	NA	<3	NA	NA	NA	NA	--
Iodomethane	<5	NA	NA	<5	NA	NA	NA	NA	--
Methylene Chloride	<3	<5	NA	<3	NA	NA	NA	NA	5
Methyl-Tertiary-Butyl Ether	NA	170	NA	NA	290	310	280	310	--
4-Methyl-2-Pentanone	<3	NA	NA	<3	NA	NA	NA	NA	--
Styrene	<2	NA	NA	<2	NA	NA	NA	NA	100
1,1,2,2-Tetrachloroethane	<2	<1	NA	<2	NA	NA	NA	NA	--
Tetrachloroethene	<1	<3	NA	<1	NA	NA	NA	NA	5
Toluene	<5	<5	<5	<5	<5	<5	<5	<5	1,000
1,1,1-Trichloroethane	<5	<1	NA	<5	NA	NA	NA	NA	200
1,1,2-Trichloroethane	<2	<2	NA	<2	NA	NA	NA	NA	5
Trichloroethene	<1	<1	NA	<1	NA	NA	NA	NA	5
Trichlorofluoromethane	<1	<1	NA	<1	NA	NA	NA	NA	--
1,2,3-Trichloropropane	<5	NA	NA	<5	NA	NA	NA	NA	--
Vinyl Acetate	<2	NA	NA	<2	NA	NA	NA	NA	--
Vinyl Chloride	<1	<1	NA	<1	NA	NA	NA	NA	2
Total Xylenes	<2	<2	26	26	11	12	19	20	10,000

Footnotes on Page 3.

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	System Effluent 3/19/93	6/24/93	10/28/93	12/21/93	4/6/94	Duplicate 4/6/94	6/22/94	Duplicate 6/22/94	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
HYDROCARBONS (µg/l)	100,000	1,900/9,200	2,900/11,000	3,200	18,000	18,000	110,000	100,000	
(Hydrocarbon Range[1])	(Diesel)	(Gas/Diesel)	(Gas/Diesel)	(Diesel)	(Diesel)	(Diesel)	(Diesel)	(Diesel)	
NON-METALLIC (mg/l)									
Total Alkalinity	680	660	690	710	250	220	680	680	--
Bicarbonate	680	660	690	710	250	220	680	680	--
Carbonate	<1	<1	<1	<1	<1	<1	2	3	--
Carbon Dioxide, Free as CaCO3	<1	52	45	140	20	17	43	34	--
Hydroxide as CaCO3	<1	<1	<1	<1	<1	<1	<1	<1	--
Sulfate	46	91	67	11	<50	<50	18	17	--
PHYSICAL PROPERTIES									
pH (Units)	7.1	7.4	7.5	7.0	7.4	7.4	7.5	7.6	--
Specific Conductance (µS/cm)	1,400	1,400	1,400	1,300	1,400	1,300	1,400	1,300	--
Hardness (mg/l)	730	770	880	840	780	810	790	800	--
Total Dissolved Solids (mg/l)	890	910	910	910	860	870	930	960	--
Total Suspended Solids (mg/l)	42	20	10	20	35	57	17	26	--

mg/l Milligrams per liter or parts per million (ppm).
µg/l Micrograms per liter or parts per billion (ppb).
µS/cm Microsiemens per centimeter.
NA Indicates the sample was not analyzed for this parameter.
< Indicates the concentration is below the detection limit; the detection limit is shown following the < symbol.
[box] Indicates the concentration has exceeded the Federal Maximum Contaminant Level.
1 Hydrocarbons quantitated using diesel range (C10-C28) or gasoline range (C6-C10).

5.18

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

	System Effluent								Federal Maximum Contaminant
		Duplicate		Duplicate		Duplicate			Levels (MCL)
Parameters	9/20/94	9/20/94	6/5/95	6/5/95	9/28/95	9/28/95	7/22/96	11/19/96	(Effective January 1994)
TOTAL METALS (mg/l)									
Arsenic	0.007	0.006	0.006	<0.010	0.007	0.007	0.006	0.009	0.05
Calcium	230	230	220	220	220	220	220	180	--
Iron	6.7	5.4	16	12	10	10	25	8.3	--
Lead	<0.003	<0.003	<0.003	<0.003	0.005	0.003	0.006	0.005	--
Magnesium	44	44	53	52	53	53	43	37	--
Manganese	0.93	0.93	0.84	0.83	0.78	0.78	0.77	0.66	--
Sodium	31	31	34	35	37	37	32	28	--
VOLATILE ORGANIC COMPOUNDS (µg/l)									
Acetone	NA	NA	NA	NA	NA	NA	NA	NA	--
Acrolein	NA	NA	NA	NA	NA	NA	NA	NA	--
Acrylonitrile	NA	NA	NA	NA	NA	NA	NA	NA	--
Benzene	55	54	31	46	70	68	<1	33	5
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Bromoform	NA	NA	NA	NA	NA	NA	NA	NA	--
Bromomethane	NA	NA	NA	NA	NA	NA	NA	NA	--
2-Butanone (MEK)	NA	NA	NA	NA	NA	NA	NA	NA	--
Carbon Disulfide	NA	NA	NA	NA	NA	NA	NA	NA	--
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	NA	NA	5
Chlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	--
Chloroethane	NA	NA	NA	NA	NA	NA	NA	NA	--
2-Chloroethyl Vinyl Ether	NA	NA	NA	NA	NA	NA	NA	NA	--
Chloroform	NA	NA	NA	NA	NA	NA	NA	NA	--
Chloromethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Chlorodibromomethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Dibromomethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Dichlorodifluoromethane	NA	NA	NA	NA	NA	NA	NA	NA	--
1,1-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	--
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	5

Footnotes on Page 6.

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9-18

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

	System Effluent								Federal Maximum Contaminant
Parameters	9/20/94	Duplicate 9/20/94	6/5/95	Duplicate 6/5/95	9/28/95	Duplicate 9/28/95	7/22/96	11/19/96	Levels (MCL) (Effective January 1994)
VOLATILE ORGANIC COMPOUNDS (continued)									
1,1-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	7
Total 1,2-Dichloroethylene	NA	NA	NA	NA	NA	NA	NA	NA	--
1,2-Dichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	5
Cis-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	--
Trans-1,3-Dichloropropene	NA	NA	NA	NA	NA	NA	NA	NA	--
1,4-Dichloro-2-Butene	NA	NA	NA	NA	NA	NA	NA	NA	--
Ethanol	NA	NA	NA	NA	NA	NA	NA	NA	--
Ethylbenzene	<1	<1	<1	<1	<1	<1	<1	<1	700
Ethyl Methacrylate	NA	NA	NA	NA	NA	NA	NA	NA	--
2-Hexanone	NA	NA	NA	NA	NA	NA	NA	NA	--
Iodomethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Methylene Chloride	NA	NA	NA	NA	NA	NA	NA	NA	5
Methyl-Tertiary-Butyl Ether	220	2,000	510	550	480	520	220	430	--
4-Methyl-2-Pentanone	NA	NA	NA	NA	NA	NA	NA	NA	--
Styrene	NA	NA	NA	NA	NA	NA	NA	NA	100
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	--
Tetrachloroethene	NA	NA	NA	NA	NA	NA	NA	NA	5
Toluene	<5	<5	<5	<5	<5	<5	<1	<1	1,000
1,1,1-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	200
1,1,2-Trichloroethane	NA	NA	NA	NA	NA	NA	NA	NA	5
Trichloroethene	NA	NA	NA	NA	NA	NA	NA	NA	5
Trichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	NA	--
1,2,3-Trichloropropane	NA	NA	NA	NA	NA	NA	NA	NA	--
Vinyl Acetate	NA	NA	NA	NA	NA	NA	NA	NA	--
Vinyl Chloride	NA	NA	NA	NA	NA	NA	NA	NA	2
Total Xylenes	<2	<2	<2	6	<2	<2	4	9	10,000

Footnotes on Page 6.

B1-7

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

	System Effluent								Federal Maximum Contaminant
Parameters	9/20/94	Duplicate 9/20/94	6/5/95	Duplicate 6/5/95	9/28/95	Duplicate 9/28/95	7/22/96	11/19/96	Levels (MCL) (Effective January 1994)
HYDROCARBONS (µg/l)	33,000	12,000	32,000	NA	14,000	20,000	3,000/120,000	2,000/59,000	--
(Hydrocarbon Range[1])	(Diesel)	(Diesel)	(Diesel)		(Diesel)	(Diesel)	(Gas/Diesel)	(Gas/Diesel)	
NON-METALLIC (mg/l)									
Total Alkalinity	640	650	700	700	630	690	68	690	--
Bicarbonate	640	650	700	700	630	690	68	690	--
Carbonate	5	2	3	<1	1	1	<5	<5	--
Carbon Dioxide, Free	16	52	35	44	130	170	15	110	--
Hydroxide	<1	<1	<1	<1	<1	<1	<10	<5	--
Sulfate	<10	<10	<10	<10	<10	<10	16	0.8	--
PHYSICAL PROPERTIES									
pH (Units)	7.9	7.4	7.6	7.5	7.0	6.9	6.9	7.1	--
Specific Conductance (µS/cm	1,200	1,200	1,400	1,400	1,400	1,400	1,500	1,400	--
Hardness (mg/l)	750	750	770	770	770	770	730	600	--
Total Dissolved Solids (mg/l)	790	850	840	820	830	810	920	850	--
Total Suspended Solids (mg/l	18	14	79	20	18	18	180	27	--

mg/l Milligrams per liter or parts per million (ppm).
µg/l Micrograms per liter or parts per billion (ppb).
µS/cm Microsiemens per centimeter.
NA Indicates the sample was not analyzed for this parameter.
< Indicates the concentration is below the detection limit; the detection limit is shown following the < symbol.
☐ Indicates the concentration has exceeded the Federal Maximum Contaminant Level.
1 Hydrocarbons quantitated using diesel range (C10-C28) or gasoline range (C6-C10).

B1-8

ARCADIS GERAGHTY & MILLER

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

B1-9

Parameters	System Effluent 6/26/97	System Effluent 10/28/97	System Effluent 7/16/98	System Effluent 11/12/98	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
TOTAL METALS (mg/l)					
Arsenic	0.005	<0.005	<0.005	<0.005	0.05
Calcium	170	190	200	190	--
Iron	79	34	20	2.9	--
Lead	0.002	0.004	0.011	<0.002	--
Magnesium	36	41	40	38	--
Manganese	0.72	0.50	0.66	0.53	--
Sodium	25	21	28	29	--
VOLATILE ORGANIC COMPOUNDS (µg/l)					
Acetone	NA	NA	NA	NA	--
Acrolein	NA	NA	NA	NA	--
Acrylonitrile	NA	NA	NA	NA	--
Benzene	<1	<1	$\boxed{17}$	<1	5
Bromodichloromethane	NA	NA	NA	NA	--
Bromoform	NA	NA	NA	NA	--
Bromomethane	NA	NA	NA	NA	--
2-Butanone (MEK)	NA	NA	NA	NA	--
Carbon Disulfide	NA	NA	NA	NA	--
Carbon Tetrachloride	NA	NA	NA	NA	5
Chlorobenzene	NA	NA	NA	NA	--
Chloroethane	NA	NA	NA	NA	--
2-Chloroethyl Vinyl Ether	NA	NA	NA	NA	--
Chloroform	NA	NA	NA	NA	--
Chloromethane	NA	NA	NA	NA	--
Chlorodibromomethane	NA	NA	NA	NA	--
Dibromomethane	NA	NA	NA	NA	--
Dichlorodifluoromethane	NA	NA	NA	NA	--
1,1-Dichloroethane	NA	NA	NA	NA	--
1,2-Dichloroethane	NA	NA	NA	NA	5

Footnotes on Page 9.

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	System Effluent 6/26/97	10/28/97	7/16/98	11/12/98	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
VOLATILE ORGANIC COMPOUNDS (continued)					
1,1-Dichloroethene	NA	NA	NA	NA	7
Total 1,2-Dichloroethylene	NA	NA	NA	NA	--
1,2-Dichloropropane	NA	NA	NA	NA	5
Cis-1,3-Dichloropropene	NA	NA	NA	NA	--
Trans-1,3-Dichloropropene	NA	NA	NA	NA	--
1,4-Dichloro-2-Butene	NA	NA	NA	NA	--
Ethanol	NA	NA	NA	NA	--
Ethylbenzene	<1	<1	<1	<1	700
Ethyl Methacrylate	NA	NA	NA	NA	--
2-Hexanone	NA	NA	NA	NA	--
Iodomethane	NA	NA	NA	NA	--
Methylene Chloride	NA	NA	NA	NA	5
Methyl-Tertiary-Butyl Ether	16	35	53	54	--
4-Methyl-2-Pentanone	NA	NA	NA	NA	--
Styrene	NA	NA	NA	NA	100
1,1,2,2-Tetrachloroethane	NA	NA	NA	NA	--
Tetrachloroethene	NA	NA	NA	NA	5
Toluene	<1	<1	<1	<1	1,000
1,1,1-Trichloroethane	NA	NA	NA	NA	200
1,1,2-Trichloroethane	NA	NA	NA	NA	5
Trichloroethene	NA	NA	NA	NA	5
Trichlorofluoromethane	NA	NA	NA	NA	--
1,2,3-Trichloropropane	NA	NA	NA	NA	--
Vinyl Acetate	NA	NA	NA	NA	--
Vinyl Chloride	NA	NA	NA	NA	2
Total Xylenes	<3	<3	<3	<3	10,000

Footnotes on Page 9.

81-10

ARCADIS GERAGHTY&MILLER

Table 4. Summary of Historical Analytical Results for System Effluent Sampling, ARCO/ECI Refinery Site, East Chicago, Indiana.

Parameters	System Effluent 6/26/97	System Effluent 10/28/97	System Effluent 7/16/98	System Effluent 11/12/98	Federal Maximum Contaminant Levels (MCL) (Effective January 1994)
HYDROCARBONS (µg/l) (Hydrocarbon Range[1])	<200/2,900 (Gas/Diesel)	<200/5,300 (Gas/Diesel)	<200/56,000 (Gas/Diesel)	<200/1,400 (Gas/Diesel)	
NON-METALLIC (mg/l)					
Total Alkalinity	750	710	710	620	--
Bicarbonate	750	710	710	620	--
Carbonate	<5	<5	<5	<5	--
Carbon Dioxide, Free	130	120	20	<5	--
Hydroxide	<5	<5	<5	<0.5	--
Sulfate	5.4	3.4	0.6	0.9	--
PHYSICAL PROPERTIES					
pH (Units)	7.0	7.1	7.75	7.27	--
Specific Conductance (µS/cm)	1,200	1,200	1,300	1,290	--
Hardness (mg/l)	570	640	660	640	--
Total Dissolved Solids (mg/l)	830	820	800	800	--
Total Suspended Solids (mg/l)	380	89	30	10	--

mg/l Milligrams per liter or parts per million (ppm).
µg/l Micrograms per liter or parts per billion (ppb).
µS/cm Microsiemens per centimeter.
NA Indicates the sample was not analyzed for this parameter.
< Indicates the concentration is below the detection limit; the detection limit is shown following the < symbol.
[ ] Indicates the concentration has exceeded the Federal Maximum Contaminant Level.
[1] Hydrocarbons quantitated using diesel range (C10-C28) or gasoline range (C6-C10).

BI-11

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Attachment B-2. RCRA Closure Requirements Design Decision

CELRC-ED-DC (1110) 21 June 1999

MEMORANDUM THRU:

CELRC-ED-C MOE 6/25

CELRC-ED-D [illegible] 6/22

CELRC-ED-G [illegible] 6/23

CELRC-ED-H [illegible] 6/24

FOR RECORD:

SUBJECT: Indiana Harbor CDF, Design Documentation Report, RCRA Closure Requirements with the Relocated Railway Design Decision

1. RECOMMENDATION: The inspection trench will be conducted prior to the installation of the cutoff wall. Scheduling will be sufficient to allow for the relocation of any utilities before the cutoff wall installation. The groundwater cutoff wall will cross the relocated railway at two locations to allow groundwater protection north and south of the railway, completely enclosing Parcels I, IIA, and IIB. The RCRA cap will be installed under the relocated railway at the ECI Site in Parcel IIB. The RCRA cap will be installed prior to the installation of the sub-ballast and ballast for the railway and, in the northern portion of the site, it will be installed as part of the railroad relocation.

2. REFERENCES:

a. Indiana Harbor and Canal Maintenance Dredging and Disposal Activities, Comprehensive Management Plan (CMP), Final Feasibility Report and Environmental Impact Statement, January 1999.

b. CSX Transportation Railroad Relocation at the Indiana Harbor Confined Disposal Facility, Design and Technical Outline Specifications and Supplementary Conditions, April 23, 1999, prepared by URS Greiner Woodward-Clyde.

3. BACKGROUND: The Indiana Harbor CDF will be constructed on the former ECI Refinery Site, Parcels I, IIA, and IIB, (enclosed figure 1). After ECI filed for bankruptcy in 1981 and abandoned the site, the bankruptcy court ordered the refinery site to be razed and capped. The cap consisted of two feet of topsoil and vegetation. The site is currently contaminated and must be encapsulated with a combination groundwater cutoff wall/ groundwater extraction system, and a RCRA cap as discussed in the CMP, reference 1a. In order to ensure complete encapsulation, the cutoff wall and RCRA cap needs to extend underneath the railway since it is inside the ECI property line. The existing CSX railway, currently crossing the site from west to east, will be relocated to the northern property boundary, reference 1b.

4. ALTERNATIVES: The alternatives that were considered were to grout the ballast in-place to effectively seal the site under the railway or construct a RCRA cap under the sub-ballast and ballast and place the railway on top of it. For the cutoff wall, the alternatives that were considered were to have the groundwater cutoff wall to cross the relocated railroad and follow along the northern property line or have the cutoff wall follow along the southern side of the relocated railway thereby eliminating crossings with the railroad. For the inspection trench, the alternatives that were considered were to conduct the trenching in conjunction with the groundwater cutoff wall installation or conduct the trenching in advance of the groundwater cutoff wall installation.

5. DISCUSSION: A three foot thick clay barrier (or equivalent) is required for closure that meets or exceeds a regulatory hydraulic conductivity requirement of 10^{-7} cm/sec, CMP page 68. The initial design submitted in the draft CMP distributed on 30 October 1995, CMP page 73 (enclosed figure 2), was based on a design where the railway was not relocated. Because of the added work and expense involved with placing the RCRA cap beneath the existing railway, it was determined that grouting the ballast in-place would meet the minimum regulatory hydraulic conductivity requirement. After written comments to the draft CMP/EIS were received in 1996, an analysis was completed which showed that moving the CSX railway spur would reduce construction costs and increase CDF capacity, CMP page 110 (enclosed figure 3). While the railway is being relocated, a RCRA cap can be installed without noticeably increasing the cost or effort needed to comply with the RCRA requirements. The RCRA cap would be extended to the property line to complete the seal. The alternative of grouting in-place does not provide the hydraulic conductivity capabilities that a RCRA cap does.

6. The groundwater cutoff wall is required to contain on-site contaminants, as well as contaminants from the dredged material. The vertical cutoff wall will extend from the groundsurface through the Calumet Aquifer to the underlying glacial till formation. The cutoff wall, in conjunction with the interior extraction well system will isolate the groundwater beneath the site from the surrounding area. This system is shown in figure 4. As mentioned in the CMP, pages 114 and115, the cutoff wall is needed as part of the RCRA closure for the onsite contamination. The alternative with no crossings will leave portions of the site (the northwest and northeast corners) without means to control the movement of groundwater, which is approximately 7.25 acres in area.

7. During the installation of the cutoff wall, there is a potential that underground utilities will be encountered. While a utility survey has been conducted, because of the conditions of the prior demolition project, it can not be certain that all utilities have been identified and located. The alternative of conducting the inspection trenching in conjunction with the cutoff wall installation has the potential of delaying the project if extensive relocations are needed if utilities are encountered.

8. RECOMMENDED ACTION: It is recommended that a RCRA cap be placed under the sub-ballast prior to installing the ballast and relocated railway at the ECI Site in Parcel IIB. The cutoff wall will extend across the relocated railway to enclose the northern portions of the site, being placed as near to the property lines of Parcels I, IIA, and IIB as possible. The inspection trenching will be conducted prior to the installation of the cutoff wall. Scheduling will be sufficient to allow for the relocation of any utilities before the installation of the cutoff wall. The design and the installation of the RCRA cap, the groundwater cutoff wall and the inspection trench shall be documented in the DDR.

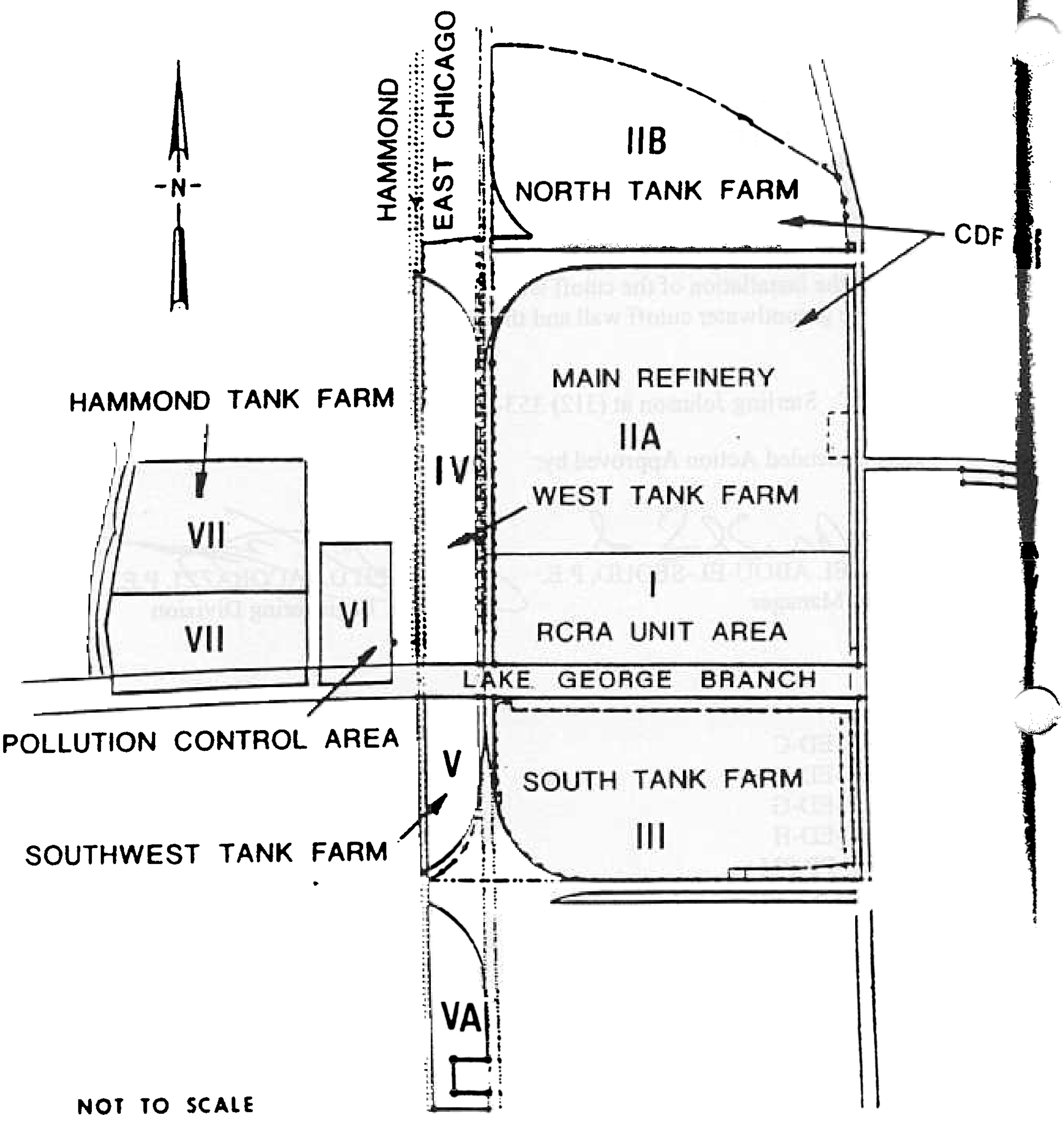
9. POC: Sterling Johnson at (312) 353-6400 ext. 3049.

Recommended Action Approved by:

SHAMEL ABOU-EL-SEOUD, P.E.
Project Manager

JOSEPH D. JACOBAZZI, P.E.
Chief, Engineering Division

cf:
CELRC-ED-C
CELRC-ED-D
CELRC-ED-G
CELRC-ED-H
CELRC-PP-PM
CELRC-RE

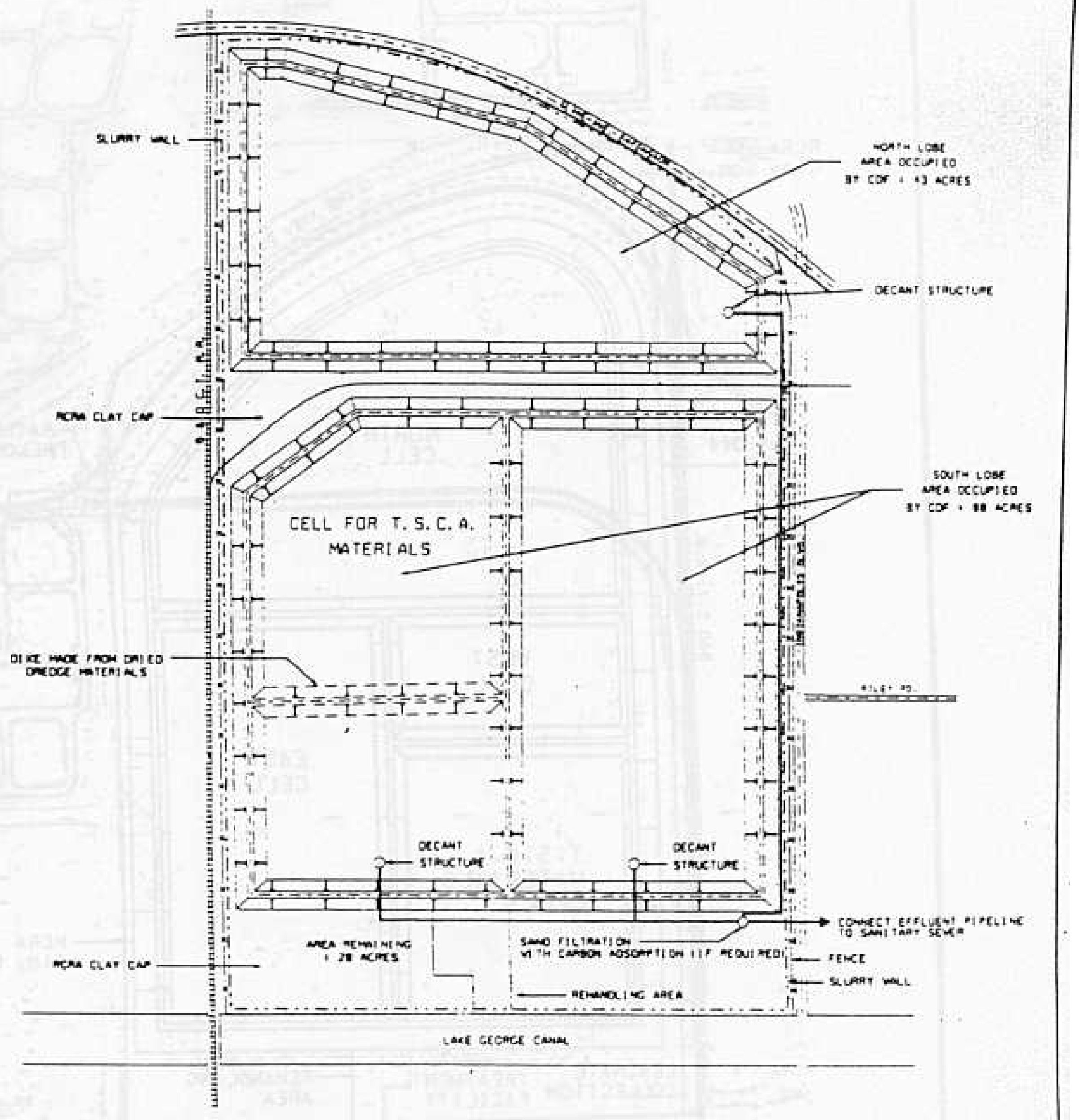


INDIANA HARBOR
CONFINED DISPOSAL FAC

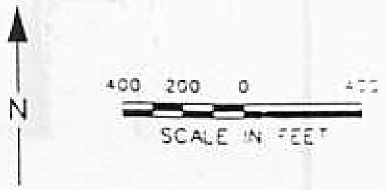
PROPERTY PARCE
ENERGY COOPERATIVE, IN

CHICAGO DISTRIC
US ARMY CORPS OF ENGI
JUNE 1993

Figure 1

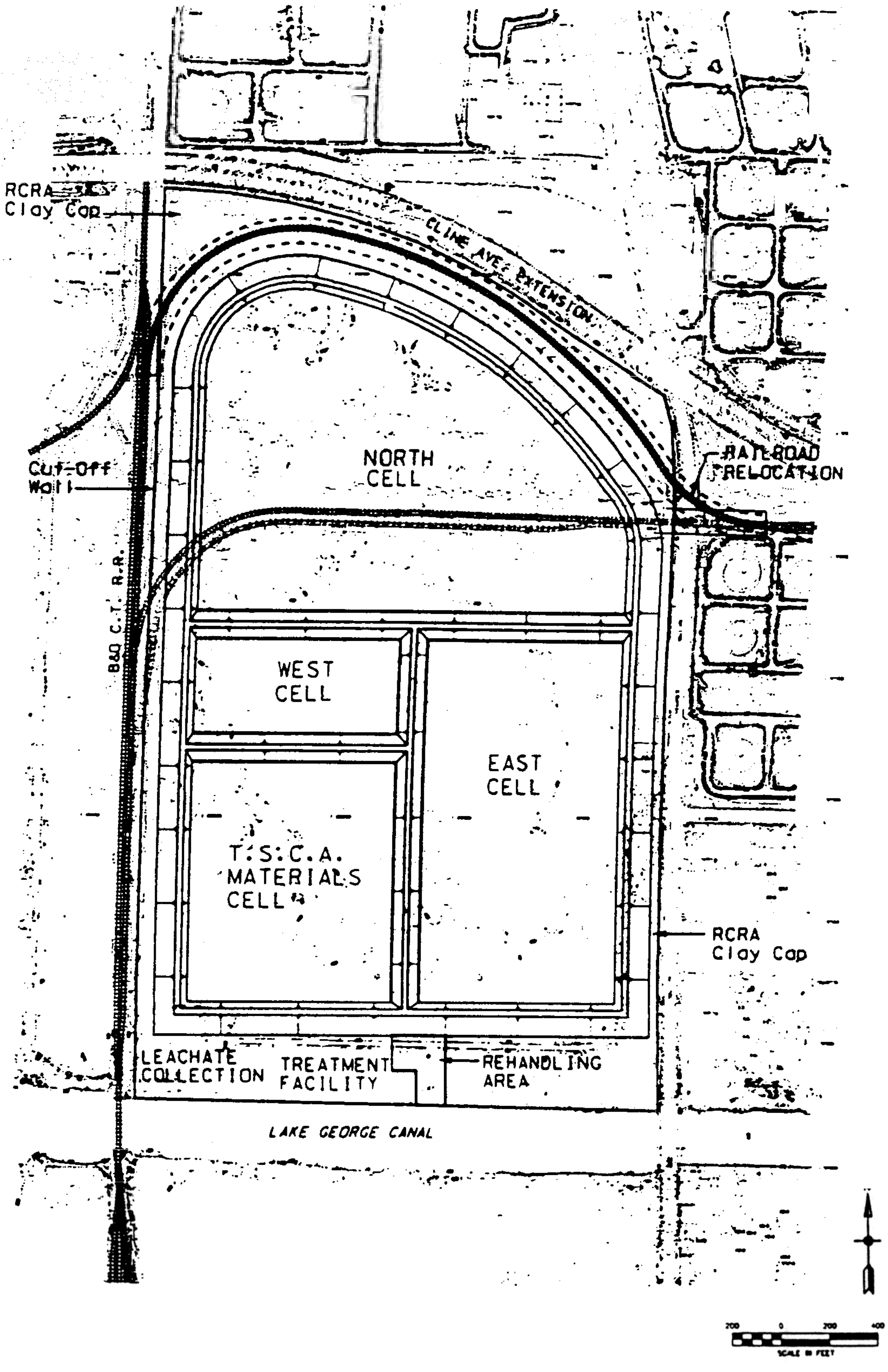


NOTE: ONLY THE TWO SOUTH LOBES WOULD BE USED IN ALTERNATIVE 1 - PARTIAL FEDERAL CHANNEL DREDGING: THE NORTH LOBE WOULD NOT BE CONSTRUCTED. THE NORTH LOBE PROPERTY WOULD BE CAPPED WITH CLAY TO COMPLETE RCRA CORRECTIVE ACTION. ALL THREE LOBES WOULD BE USED IN ALTERNATIVE 2 - COMPLETE FEDERAL CHANNEL DREDGING AND ALTERNATIVE 3 - COOPERATIVE DREDGING PROGRAM.



INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE
RCRA CLOSURE/CORRECTIVE ACTION
WITH CDF PROJECT
PLAN VIEW
CHICAGO DISTRICT CORPS OF ENGINEERS
JUNE 1993

Figure 2



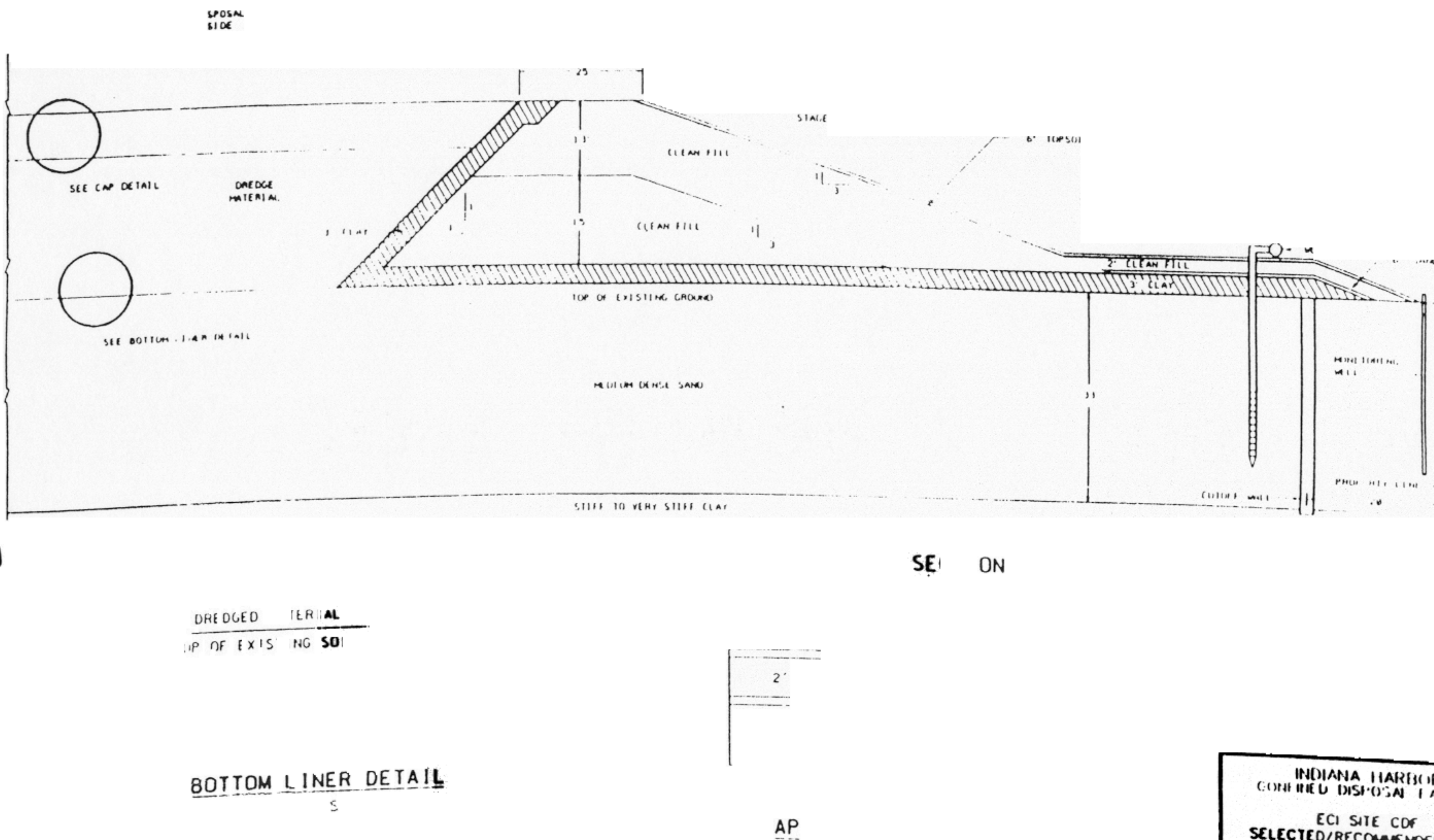
INDIANA HARBOR
CONFINED DISPOSAL FACILITY
ECI SITE CDF

SELECTED/RECOMMENDED PLAN
PLAN VIEW

Chicago District
U.S. Army Corps of Engineers
JULY 1997

B2-6

Figure 3



INDIANA HARBOR
CONFINED DISPOSAL FACILITY

ECI SITE CDF
SELECTED/RECOMMENDED PLAN
SECTION VIEW

CHICAGO DISTRICT
US ARMY CORPS OF ENGINEERS
JULY 1997

82 7

Figure 4

Attachment B-3. Coordination Letter from Indiana Department of Environmental Management

Indiana Department of Environmental Management

We make Indiana a cleaner, healthier place to live

Evan Bayh
Governor

Michael O'Connor
Commissioner

100 North Senate Avenue
P.O. Box 6015
Indianapolis, Indiana 46206-6015
Telephone 317-232-8603
Environmental Helpline 1-800-451-6027

VIA CERTIFIED MAIL - Z339-776-006

October 9, 1996

Mr. Richard E. Carlson
Deputy District Engineer
Department of the Army
Chicago District, Corps of Engineers
111 North Canal Street
Chicago, Illinois 60606-7206

Dear Mr. Carlson:

Re: Design Analysis Issues
Indiana Harbor Confined Disposal Facility
ECI Site
East Chicago, Indiana

The Indiana Department of Environmental Management (IDEM) acknowledges receipt of your letter to Ms. Kay Nelson, dated March 18, 1996, regarding the design of the Indiana Harbor Confined Disposal Facility (CDF). In the letter you raised several questions which relate to IDEM involvement in the Energy Cooperative, Inc. (ECI) CDF.

Staff from the Office of Solid and Hazardous Waste Management (OSHWM) have attempted to answer your questions as thoroughly as possible. However, it should be noted that some of your questions are general, so the level of detail in the answers is also quite general. As noted, several of the topics require further discussion between all parties to coordinate future actions.

At an interagency meeting on August 28, 1996, between the USACOE, US EPA, IDEM and the East Chicago Waterway Management District, these issues were discussed, but a separate program specific meeting was requested between the US EPA and IDEM. The purpose of the US EPA/IDEM meeting was to clarify program authority for the remedial actions at the site. The outcome of that meeting was that the ECI site shall be considered one RCRA unit for purposes of closure, and will therefore be under the regulatory authority of OSHWM of IDEM as discussed in the following response to questions.

If you have any questions or wish to set up a meeting following your review of this document, please contact Mr. Stephen West of this office at 317/232-3397.

Sincerely,

Victor P. Windle

Thomas E. Linson, Chief for
Hazardous Waste Facilities Branch
Solid and Hazardous Waste Management

SDW

cc: Mr David Petrovski, US EPA, Region V
Ms. Kay Nelson, NWRO
Ms. Mary Fulghum, NWRO
Ms. Jody Bremmer, OLC
Ms. Lynnette Fogle, OER
Mr. Brad Gavin, OLC
Mr. Scott Ireland, OWM
Mr. George Richotte, OSHWM

U.S. Army Corps of Engineers
Design Analysis Issues
Indiana Harbor Confined Disposal Facility
E.C.I. Site
East Chicago, Indiana

1. Question: *Consideration is being given to various types of vertical subsurface cut-off wall options, including soil-bentonite slurry wall, cement-bentonite slurry wall, and a combination vibrated beam and vertical HDPE membrane (with joint filler) cut-off wall. From a regulatory standpoint, are these acceptable alternatives for the cut-off wall construction?*

   Response: There are no regulatory restrictions for the type of slurry wall chosen. A slurry wall may be used as a barrier to ground water migration, and as such, is regulated by performance standards, rather than regulatory standards.

2. Question: *During clearing and grubbing and other construction activities at the site, can on-site materials such as soil, concrete, pipe, etc., encountered and removed during construction be temporarily stockpiled on site and later permanently disposed of in the CDF?*

   Response: Since the site is considered the RCRA unit, there are no limitations on the movement of waste within the unit. However, if the soil, construction debris, etc. is to be removed from the site, it must be sampled and analyzed to determine whether it contains hazardous waste. The material may be disposed of on-site in the CDF. Placing or replacing hazardous wastes from within a RCRA unit will not trigger land disposal restrictions (LDRs) (40 CFR Part 268).

3. Question: *Can the on-site soil that is removed from the perimeter cut-off trench be blended with bentonite and placed back into the trench to form the cut-off wall?*

   Response: As stated in the response to number 2 above, the soil may be managed within the RCRA unit without triggering LDRs.

4. Question: *Will it be possible to temporarily stockpile on-site, for permanent disposal within the CDF, any excess soil removed from the perimeter cut-off trench that is not needed for construction of the slurry or cut-off wall?*

   Response: See response to question number 2.

5. Question: *Will it be possible to place excess slurry from the perimeter cut-off wall construction in the CDF?*

Response: See response to question number 2.

6. Question: *Can on-site soils be used for dike construction?*

Response: See response to question number 2.

7. Question: *Do excavated materials temporarily stored on-site need to be covered prior to disposal into the CDF or removal off-site?*

Response: No. As stated above, the material is being managed in the RCRA unit, rather than being "stored," and therefore does not require covering.

8. Question: *What will be the requirements, if any, for handling surface runoff or groundwater generated or collected during construction and prior to having the runoff and groundwater management systems in-place?*

Response: This question generally applies to NPDES stormwater permitting, however, run-off or generated ground water which exhibits a characteristic of hazardous waste should be managed to contain it and prevent release from the site.

9. Question: *What are the RCRA requirements in connection with the ECI site investigations, construction, operations, and monitoring plan?*

Response: The owner/operator are responsible for submitting a closure plan and post-closure plan to address contamination associated with the RCRA unit. The closure plan will consist of the design, construction procedures, and maintenance planning for the site. Following approval of the closure plan and post-closure plan, the owner/operator shall implement the closure plan which will consist of construction of the CDF. Concurrently, the parties (USACOE, East Chicago Waterway Management District, and IDEM) will enter into an agreement to fulfill the requirements of the post-closure plan. Generally, this is done through the issuance of a post-closure permit, but since the closure of the unit will not be completed until the CDF is filled and capped, a permit is inappropriate. Until the CDF is filled and capped in approximately 2035, a formal agreement should be in place to provide a framework for post-closure care. This agreement should be structured such that modification is easily accomplished by any party following approval of the other parties, to account for changes in technology or regulatory interpretation. This issue will be discussed further following your meeting with the East Chicago Waterway Management District Board.

10. Question: *What are the TSCA requirements in connection with disposal of the PCB sediments within the CDF?*

Response: Pursuant to 40 CFR 761.60(a)(5), all dredged materials and municipal sewage that contains 50 parts per million of PCBs or greater shall be disposed of in a Toxic Substances Control Act (TSCA) incinerator, a chemical waste landfill, or, with approval from the Agency's Regional Administrator, by use of an alternative disposal method. This approval requires the applicant to demonstrate that based on technical, environmental, or economical considerations, disposal in an incinerator and/or chemical waste landfill is not reasonable and appropriate and that the alternative method will provide adequate protection to the environment.

Furthermore, since the State of Indiana adopted a majority of the 1982 version of the federal TSCA regulations, including 40 CFR 761.60(a)(5), in accordance with 329 IAC 4-1-5(7) the applicant must also gain approval from the Commissioner of IDEM prior to selecting an alternative disposal method. This is another topic that requires further discussion. IDEM will coordinate with the US EPA to the extent practicable on the issuance of the TSCA permit.

Attachment B-4. Comparative Cost Estimate for Groundwater Cutoff Wall Options

REASONABLE CONTRACT ESTIMATE WORKSHEET SUMMARY

PROJECT: INDIANA HABOR CDF — Length 10,800 LF

SUBJECT: OPTION 1 - SOIL-BENTONITE SLURRY WALL — QUANTITY 356,400 SF

	PLANT	LABOR	MATERIALS	SUPPLIES	SUBTOTAL	REF PG
1. MOBILIZATION AND SITE PREPARATION					$ 100,000.	
2. EXCAVATE SLURRY PONDS	$ 346	$ 338			$ 684	
3. BENTONITE SOIL SLURRY WALL	$ 410,379	$ 604,389	$ 364,485		$ 1,379,253	
4. SLURRY WASTE DISPOSAL	$ 1,906	$ 2,368	$ 96,525		$ 100,799	
SUB-TOTAL					$ 1,580,736	
MARKUPS - 30.76 %					486,234	
SUB-TOTAL					2,066,970	
CONTINGENCY - 20 %					413,394	
TOTALS					$ 2,480,364	

ENG. FORM 1740 AUG 69 (EM 1110-2-1302)

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR CDF

SUBJECT
SOIL BENTONITE SLURRY WALL

BID ITEM #

QUANTITY

PLAN OF OPERATIONS

1. EXCAVATE SLURRY PONDS
2. SETUP SLURRY EQUIPMENT
   a. SLURRY MIXER, BENTONITE SILOS, BATCH SCALES
   b. SLURRY PUMPS PIPE & HOSES
   c. AIR LIFT PUMP.
   d. CYCLONE DESANDER.
   e. SKIFF W/ OUTBOARD MOTOR (POND AGITATOR)
   f. PIPING HOSE & VALVE
3. CONSTRUCT WORKING PLATFORM OVER TRENCH.
4. PREPARE BENTONITE SLURRY. MIX BENTONITE W/ WATER.
5. EXCAVATE SLURRY TRENCH W/ BACKHOE / CLAMSHELL.
6. PUMP SLURRY FROM HOLDING POND TO TRENCH.
7. WIND ROW BACKFILL ALONG THE SIDE OF TRENCH.
8. BLEND SLURRY MIX INTO MATERIAL EXCAVATED FROM THE TRENCH BY SLUICING THE SLURRY INTO THE FILL AND MIXING THE MASS TOGETHER W/ A BULLDOZER UNTIL THE BACKFILL HAS A SLUMP OF 6 TO 8 INCHES.
9. PUSH THE BACKFILL INTO THE TRENCH DISPLACING THE SLURRY.
10. EXCESS SLURRY IS PUMPED BACK TO THE RECOVERY POND FOR REUSE.
11. UPON COMPLETION ALL EXCESS SLURRY IS HAULED AWAY.

REASONABLE CONTRACT ESTIMATE WORKSHEET

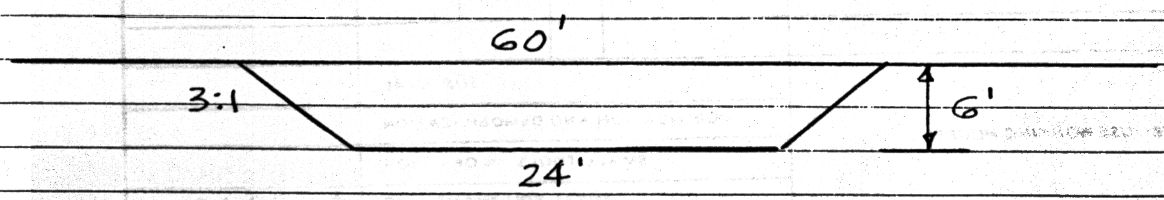
PROJECT
INDIANA HARBOR CDF

SUBJECT
EXCAVATE SLURRY PONDS

BID ITEM #

QUANTITY

PLAN OF OPERATIONS



EXCAVATION :

$A_1 = 60 \times 60 = 3{,}600$ SF

$A_2 = 24 \times 24 = 576$

VOLUME $= \frac{3600 + 576}{2} \times \frac{6}{27} = 464$ CY

EXCAVATE 2 PONDS VOL = 928 CY
1. POND FOR SLURRY HYDRATION
2. SLURRY POND

EXCAVATE PONDS W/ A BULLDOZER

PRODUCTION PUSH 100 FT.

PUSH 100 FT./1.5 MPH X 88 FT/MIN/MPH	=	0.75 MIN.
FIXED TIME	=	0.10
RETURN 100 FT./2.5 X 88	=	0.45
		1.30 MIN.

$P = 4.38 \text{ LCY} \times .8 \times \frac{50 \text{ MIN/HR}}{1.30 \text{ MIN./CYCLE}} = 135 \text{ BCY/HR}$

$T = \frac{928 \text{ CY}}{135 \text{ CY/HR}} = 7$ HRS. SAY 8 HRS

REASONABLE CONTRACT ESTIMATE WORKSHEET

SHEET 4 OF 14

SUBJECT: EXCAVATE SLURRY PONDS

QUANTITY:

EQUIPMENT

UNIT OF EQUIPMENT	SIZE	NO	HOURS*	RATE	AMOUNT
BULLDOZER, CAT D-6	140 HP	1	8	39.15	$ 313
BLADE D-6	4.38 CY	1	8	4.08	33
(*NOTE: USE WORKING HOURS)				SUBTOTAL	
				MOBILIZATION AND DEMOBILIZATION	
				SMALL TOOLS % OF LABOR	
				TOTAL EQUIPMENT COST	$ 346

LABOR

OPERATION	CRAFT	NO.	HOURS	RATE	AMOUNT
	OPERATOR	1	8	42.24	$ 338
				TOTAL LABOR COST	$ 338

MATERIALS

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
			TOTAL MATERIALS COST	

SUPPLIES

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
			TOTAL SUPPLIES COST	

TOTAL FOR TRANSFER TO ENG FORM 1739 OR 1740	$ 684

REMARKS (Indicate by asterisk (*) prices on items which are based on quotations from manufacturers or suppliers.)	DATE	PREPARED BY
		CHECKED BY

ENG FORM 1741c, Nov 81 EDITION OF NOV 67 MAY BE USED (EM 1110-2-1302) (Proponent: DAEN-CWE-BA)

U.S. G.P.O. 1983-403-722/7671

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR, CDF

SUBJECT: BENTONITE SOIL SLURRY WALL
BID ITEM #
QUANTITY: V = 39,600 CY

PLAN OF OPERATIONS

SLURRY TRENCH EXCAVATION

SLURRY ESTIMATE:

1. LENGTH OF TRENCH = 10,800 LF
2. AVERAGE DEPTH = 33 FT.
3. TRENCH WIDTH = 3 FT.

$$\text{VOLUME} = \frac{10{,}800 \times 33 \times 3}{27} = 39{,}600 \text{ CY}$$

$= 1{,}069{,}200$

BENTONITE ESTIMATE:

1. BENTONITE @ 6% WT. WATER

$$V = \frac{1000 \text{ CY @ } 7 \text{ CF/CY} \times 62.4 \text{ LBS/CF} \times 6\%}{2000 \text{ LB/TON}}$$

$= 50$ TON / 1000 CY

2. BENTONITE REQUIRED

WT. = 39,600 CY × 50 TON/1000 CY
= 1,980 TON

3. RECOVERY FOR REUSE = 65%

MAKE-UP = 1,980 × 35% = 693 TONS

+ 1 PANEL (400' × 33' × 3')(.65)(62.4 × .06)(1/2000 LB/TON)
= 48 TONS

ADD BENTONITE SLURRY TO BACKFILL MIXTURE

$$= \frac{1{,}069{,}200 \times 120 \text{ LB/CF} \times 4\%}{2000 \text{ LB/TON}} = 2{,}566 \text{ TONS}$$

TOTAL BENTONITE REQ = 693 + 48 + 2,566 = 3,307 TONS

$$\text{WATER} = \frac{3{,}307 \text{ TON} \times 2000 \text{ LB/TON} \times 94\% \times 1.15}{.06 \times 8.33 \text{ LB/GAL}} = 14{,}300{,}000 \text{ GAL}$$

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR CDF

SUBJECT
BENTONITE SOIL SLURRY WALL

BID ITEM #

QUANTITY
V = 39,600 CY

PLAN OF OPERATIONS
SLURRY TRENCH EXCAVATION

THE TRENCH EXCAVATION, SLURRY PREPARATION AND PLACEMENT OF THE BACKFILL WILL BE DONE AT THE RATE OF 42 CY/HR. (AVE. DEPTH = 33 FT.)

THE SLURRY TRENCH WILL BE EXCAVATED W/ A BACKHOE CAT 325 L LONG REACH HAVING A MAXIMUM DIGGING DEPTH OF 48 FT, W/ A BUCKET WIDTH OF 32 IN. AND BUCKET CAPACITY OF 0.62 CY.
TRENCH WIDTH = 36 IN.

$$\text{EXCAVATION} = 0.62 \times 0.8 \times .95 \times \frac{60 \text{ SEC/MIN.}}{30 \text{ SEC/CYCLE}} \times 45 \text{ MIN/HR}$$

$$= 42 \text{ CY/HR.}$$

PROJECT TIME:

1. CLAMSHELL – 800 CY = 32 HR
2. BACKHOE $\frac{39{,}600 \text{ CY} - 800 \text{ CY}}{42 \text{ CY/HR}}$ = 924 HR

TOTAL = 956 HR.

SLURRY WILL BE MIXED W/ HIGH SHEAR PUMP MIXER

CYCLE TIME 2 TO 3 MINS.

PRODUCTION 2 MIXERS IN TANDEM 1.5 MIN./MIXER

$$\text{TIME} = \frac{45 \text{ MIN/HR} \times 1.5 \text{ CY}}{1.5 \text{ MIN.}} = 45 \text{ CY/HR.}$$

REASONABLE CONTRACT ESTIMATE WORKSHEET

(EM 1110-2-1302)

SUBJECT: SLURRY WALL PLACEMENT

QUANTITY: 39,600 CY

EQUIPMENT

UNIT OF EQUIPMENT	SIZE	NO.	HOURS*	RATE	AMOUNT
CLAMSHELL CAT 3256	1 CY	1	32	64.12	$ 2,052.
BUCKET	3/4 CY	1	32	2.31	74.
BACKHOE	0.62 CY	1	924	40.00	36,960
SLURRY MIXER W/PUMP & SUMP	1.5 CY	2	956	10.00	19,120.
AIR LIFT PUMP W/ COMPRESSOR		1	956	10.00	9,560.
TRASH PUMP 4"Ø	625 GPM	3	956	2.60	7,457.
CYCLONE		1	956	5.00	4,780.
BULLDOZER D-6	140 HP	2	956	39.15	74,855.
BLADE		2	956	4.08	7,801.
MOTOR BOAT	10 HP	2	956	3.50	6,692.
WATER TANK 63 HP	6,000 GAL	3	956	9.26	26,558.
WATER TRUCKS	6,000 GAL	3	956	46.61	133,677.
SILOS 10 CF	160 TON	2	956	8.07	15,430.
SCREW FEEDER		2	956	2.92	5,583.
SCALES & BATCHES		1	956	2.00	1,912.
	SUBTOTAL				352,511
*NOTE: USE WORKING HOURS	SMALL TOOLS 3 % OF LABOR				18,127
	TOTAL EQUIPMENT COST				370,638

LABOR

OPERATION	CRAFT	NO.	HOURS	RATE	AMOUNT
BACKHOE/CLAM	FOREMAN	1	956	43.24	$ 41,337.
	OPERATOR	1	956	42.24	40,381.
	OILER	1	956	36.39	34,789.
TRASH PUMP	OPERATOR	1	956	39.39	37,657.
MIXER	OPERATOR	1	956	39.39	37,657.
BOAT	OPERATOR	1	956	39.39	37,657.
BULLDOZER	OPERATOR	2	956	42.24	80,763
WATER TRUCKS	DRIVER	3	956	34.81	99,835.
	LABORER	6	956	26.81	153,782.
CRANE OPERATOR		1	956	42.24	40,381.

REASONABLE CONTRACT ESTIMATE WORKSHEET

(EM 1110-2-1302)

SHEET 8 OF 14

SUBJECT: SLURRY WALL PLACEMENT

QUANTITY: 39,600 CY

EQUIPMENT CONT'T

UNIT OF EQUIPMENT	SIZE	NO.	HOURS*	RATE	AMOUNT
VIBRATOR		1	956	5.00	$ 4,780.
R 7 CRANE	18 TON	1	956	35.05	33,508.
WATER PUMP - 17,600 GPH	3"φ	1	956	1.52	1,453
*NOTE: USE WORKING HOURS				SUBTOTAL	$ 39,741.
	SMALL TOOLS ~~% OF LABOR~~				$ 370,638
				TOTAL EQUIPMENT COST	$ 410,379

LABOR

OPERATION	CRAFT	NO.	HOURS	RATE	AMOUNT
				TOTAL LABOR COST	

ENG FORM 1741a, Nov 81 EDITION OF NOV 67 MAY BE USED (Proponent: DAEN-CWE-BA)

REASONABLE CONTRACT ESTIMATE WORKSHEET
(EM 1110-2-1302)

SHEET 9 OF 1

SUBJECT: SLURRY WALL PLACEMENT

QUANTITY: 39,600 CY

MATERIALS

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
BENTONITE	TON	3,307	110.	$ 363,770.
WATER - 14,300,000 GAL / 1000 GAL	MGAL	14,300	.05	715
			TOTAL MATERIALS COST $ 364,485

SUPPLIES

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
			TOTAL SUPPLIES COST

SUMMARY FOR TRANSFER TO ENG FORM 1739 OR 1740

EQUIPMENT	$ 410,379
LABOR	604,389
MATERIALS	364,485
SUPPLIES	
TOTAL	$ 1,379,253

REMARKS: **Prices on these items are based on quotations from manufacturers or suppliers*

DATE

PREPARED BY

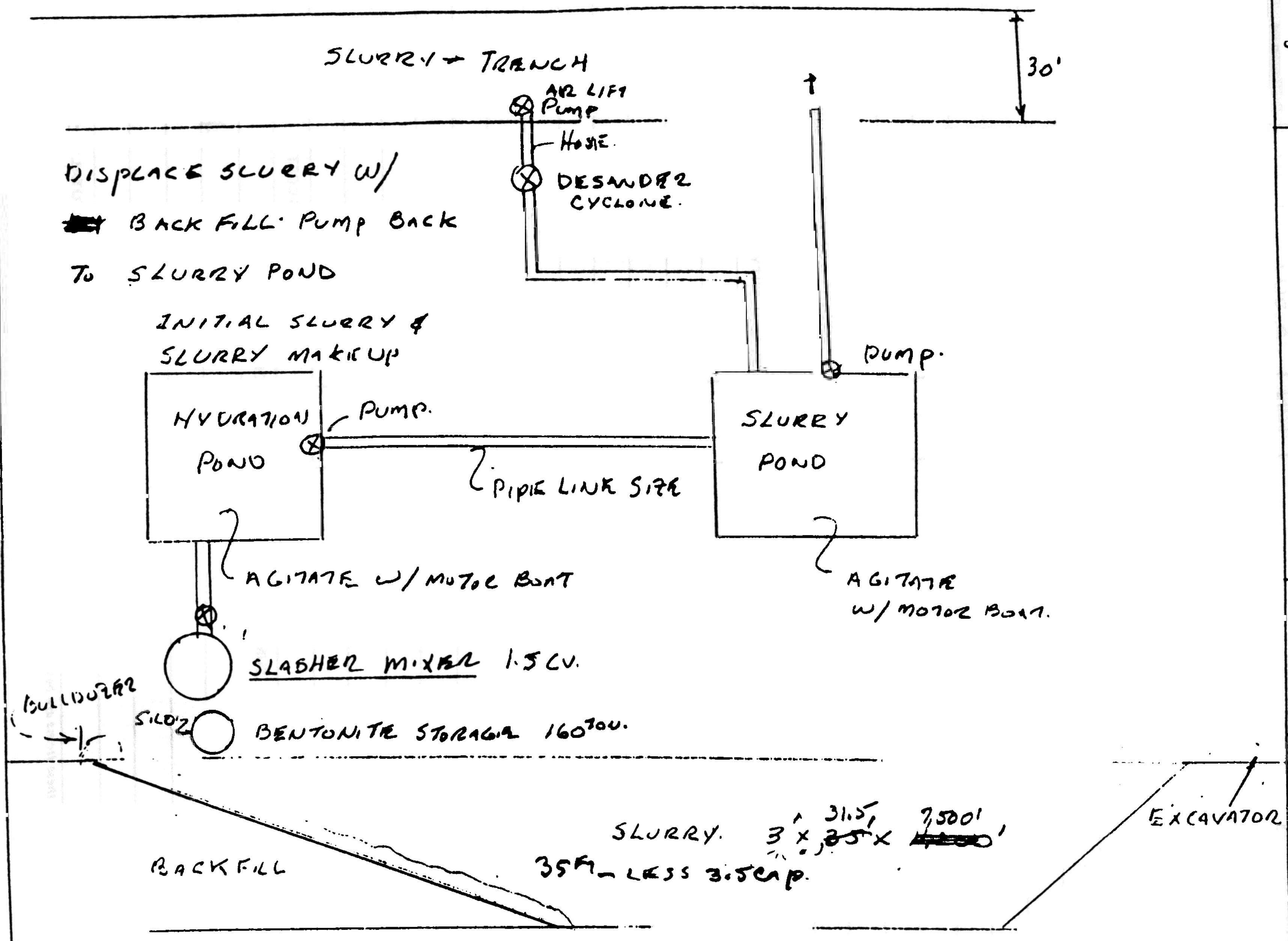
CHECKED BY

ENG FORM 1741b, Nov 81 EDITION OF NOV 67 MAY BE USED. * GPO: 1982-385-473/697 *(Proponent: DAEN-CWE-BA)*

TRENCH EXCAVATION STOCKPILED, MIXED W/SLURRY & RETURN TO TREN

NCC Form 1272-1, May 84

B4-10



US Army Corps of Engineers

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SHEET: 10

CONTRACT NO: 14

US Army Corps of Engineers
Chicago District

PROJECT TIT

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SHEET: 11

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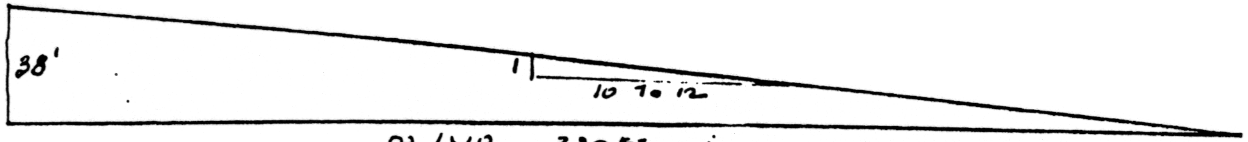
THE FIRST 420 FT. OF TRENCH SLURRY MIXED BACKFILL W/A SLUMP OF 6 TO 8 INCHES WILL BE PLACED WITH A CLAMSHELL



@ 1:10 380 FT

@ 1:12 456 FT.

:10 (1) BACKFILL $\frac{38^{FT} \times 380^{FT} \times 3^{FT}}{2 \times 27^{FT^3}/CY}$ = 802 CY.

1:12 (2) BACKFILL $\frac{38^{FT} \times 456^{FT} \times 3^{FT}}{2 \times 27^{FT^3}/CY}$ 962 CY.

SAY 800 CY.

CLAMSHELL HD. WT. 3,845 LB.

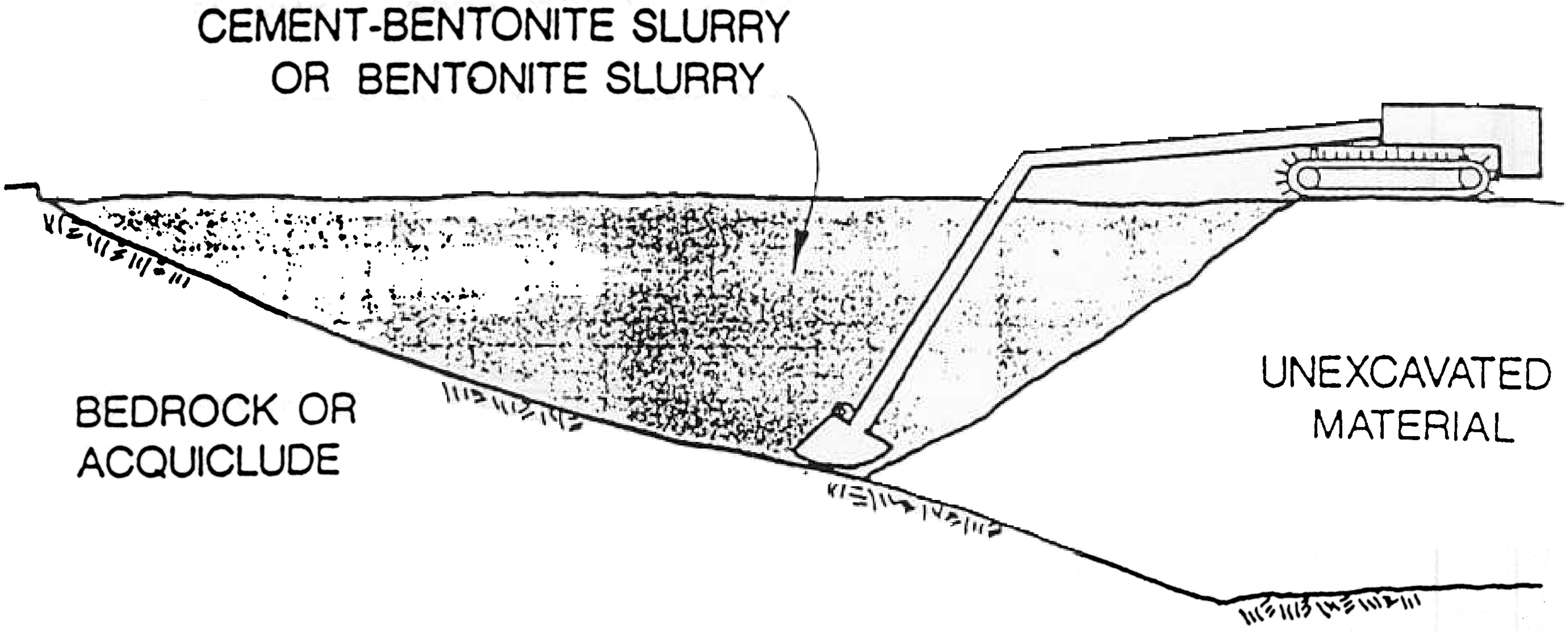
BUCKET CAPACITY 3/4 CY WIDTH 2'-10"

P = 0.75 CY × .8 (BF) × .90 (FILL FACTOR) × 1 MIN CYCLE × 45 MIN HR. = 24 CY/HR.

PROJECT TIME 800 CY / 24 CY/HR. = 33 HR SAY 4 DAYS

B4-11

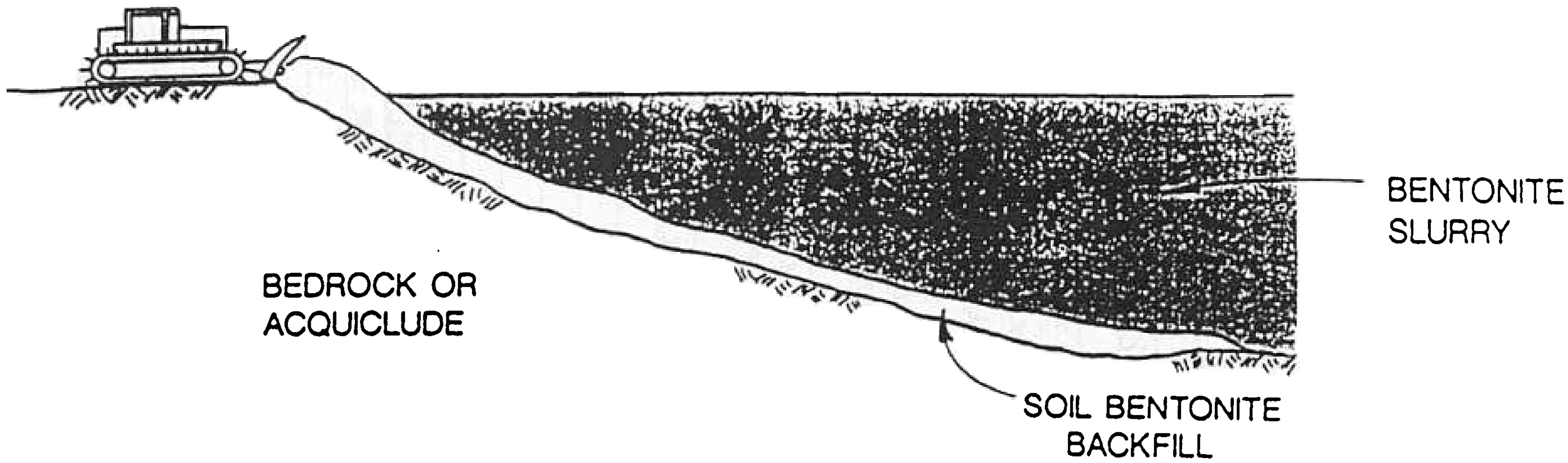
B4-12



OPEN TRENCH CUTOFF WALL—TYPICAL EXCAVATION UNDER SLURRY

Source: D.B. Paul, R.R. Davidson, and N.J. Cavalli, Slurry Design, Construction, and Quality Control.

Sheet 12 of



B4-13

SOIL-BENTONITE CUTOFF WALL—TYPICAL BACKFILL PROCEDURE

Source: D.B. Paul, R.R. Davidson, and N.J. Cavalli, Slurry Design, Construction, and Quality Control.

Sheet 12 of 14

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR CDF

SUBJECT	BID ITEM #	QUANTITY
SLURRY WASTE	DISPOSAL	V = 193,050 GAL

PLAN OF OPERATIONS

BENTONITE PURCHASED FOR SLURRY TRENCH

COMPUTE SLURRY VOLUME TO BE WASTED

SLURRY VOL. = 400 X 33 X 3 X .65
= 25,740 CF X 7.5 CF/GAL
= 193,050 GAL

HAUL SLURRY TO DISPOSAL AREA
USE 6000 GAL TANKERS FOR HAULING
CYCLE TIME / TRK
1. LOAD TRUCK 6000 GAL W/ 4" TRASH PUMP
T = 6000 GAL / 500 GPM = 12 MIN.

2. HAUL TIME UP & BACK - 20 MI/30 MPH = 40 MIN.

3. FIXED TIME = 2 MIN.

4. UNLOAD = 12 MIN.

= 66 MIN.

SAY 1 HR. TO COMPLETE CYCLE

PUMP PRODUCTION = 500 GPM X 60 MIN/HR = 30,000 GPH

TANKERS REQUIRED = $\frac{30,000 \text{ GPH}}{6000 \text{ GAL/TRK HR}}$ = 5 TRUCKS

PROJECT TIME = $\frac{193,050}{30,000 \text{ GPH}}$ = 8 HRS.

REASONABLE CONTRACT ESTIMATE WORKSHEET	SHEET 14 OF
SUBJECT SLURRY WASTE DISPOSAL	QUANTITY 193,050 GAL

EQUIPMENT

UNIT OF EQUIPMENT	SIZE	NO	HOURS*	RATE	AMOUNT
PUMP	4" ∅	2	8	2.60	$ 42.
TANKERS	6000 GAL	5	8	46.61	1,864
				SUBTOTAL	
				MOBILIZATION AND DEMOBILIZATION	
(*NOTE: USE WORKING HOURS)				SMALL TOOLS % OF LABOR	
				TOTAL EQUIPMENT COST	$ 1,906.

LABOR

OPERATION	CRAFT	NO.	HOURS	RATE	AMOUNT
	FOREMAN	1	8	43.24	$ 346.
	OPERATOR	2	8	39.39	630.
	DRIVER	5	8	34.81	1,392
				TOTAL LABOR COST	$ 2,368.

MATERIALS

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
SLURRY WASTE	GAL.	193,050	0.50	$ 96,525
			TOTAL MATERIALS COST	$ 96,525

SUPPLIES

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
			TOTAL SUPPLIES COST	

TOTAL FOR TRANSFER TO ENG FORM 1739 OR 1740	$ 100,799

REMARKS (Indicate by asterisk (*) prices on items which are based on quotations from manufacturers or suppliers.)	DATE	PREPARED BY
		CHECKED BY

ENG FORM 1741c, Nov 81 EDITION OF NOV 67 MAY BE USED (EM 1110-2-1302) (Proponent: DAEN-CWE-BA)

☆ U.S. G.P.O. 1983-403-722/7871

PROJECT INDIANA HARBOR CDF

SUBJECT OPTION 2 - VIBRATING BEAM CUTOFF WALL

QUANTITY 356,400 SF

L = 10,800 LF

	PLANT	LABOR	MATERIALS	SUPPLIES	SUBTOTAL	REF PG
1. MOBILIZATION AND DEMOBILIZATION					$ 100,000.	
2. VIBRATING BEAM CUTOFF WALL	$ 392,218	$ 452,178.	$ 78,642		$ 923,038	
					$ 1,023,038	
MARKUPS - 30.76 %					$ 314,686	
SUB-TOTAL					$ 1,337,724	
CONTINGENCY - 20 %					$ 267,545	
TOTAL					$ 1,605,269	

TOTALS

(EM 1110-2-1302)

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR CDF

SUBJECT
OPTION 2 - VIBRATING BEAM CUTOFF WALL

BID ITEM #

QUANTITY
A = 356,400 SF

PLAN OF OPERATIONS

DRIVING AND EXTRACTION OF VIBRATING BEAM

1. THE SLURRY WALL SHALL BE CONSTRUCTED USING SUITABLE EQUIPMENT FOR ATTAINING REQUIRED DEPTH AND CONTINUITY OF THE WALL.

2. THE BEAM SHALL BE CONTROLLED BY GUIDE LEADS TO ASSURE PLUMBNESS IN VERTICAL PLANE WITHIN LIMITS OF 1% AND EACH INSERTION SHALL OVERLAP PREVIOUS INSERTION A MINIMUM OF 10% OF BEAM DEPTH.

3. THE BEAM SHALL BE INSERTED BY A VIBRATORY DRIVER OF A MINIMUM CAPACITY OF 17 TONS AT MAX. RATE AND EXTRACTED AT THE RATE OF 9' PER MIN.

4. AS THE VIBRATING HAMMER SINKS THE BEAM INTO THE SOIL, SLURRY SHALL BE INJECTED TO LUBRICATE THE BEAMS DOWNWARD PATH. THE SLURRY SHALL FLOW THRU 3 JETS AT THE BOTTOM OF THE BEAM. THE COMPLETE SLURRY WALL SHALL BE PLASTIC AND CONTINUOUS W/ NO GAPS AND SHALL HAVE A MIN. THICKNESS OF 6 INCHES.

5. ALL SLURRY FOR VIBRATING BEAM INJECTION SHALL BE MIXED IN A COLLOIDAL CONTINUOUS MIXING. MIXING WATER AND BENTONITE SHALL CONTINUE UNTIL BENTONITE PARTICLES ARE FULLY HYDRATED AND RESULTING SLURRY IS HOMOGENOUS. SLURRY SHALL BE PUMPED FROM CENTRALLY LOCATED MINING PLANT TO A HOLDING TANK EQUIPPED W/ A CONSTANT AGITATOR.

Sheet 3 of

REASONABLE CONTRACT ESTIMATE WORKSHEET

PROJECT
INDIANA HARBOR CDF

SUBJECT	BID ITEM #	QUANTITY
OPTION 2 - VIBRATING BEAM CUTOFF WALL		A = 356,400 SF

PLAN OF OPERATIONS

PRODUCTION

TRAVEL & POSITIONING = 1.6 MIN.

BEAM INSERTION 33 FT @ 9 FT./MIN. = 3.7 MIN.

REMOVAL @ SAME RATE = 3.7 MIN.

CYCLE TIME = 9.0 MIN.

LENGTH OF CUTOFF WALL = 10,800 LF

BEAM SIZE: D = 30", FLANGE = 15", WT. = 290 lbs./FT.

EACH INSERTION = 27"

$$\text{PRODUCTION TIME} = \frac{10{,}800' \times 9.0\ \text{MIN} \times 60}{27/12 \times 60\ \text{MIN/HR} \times 45} = 960\ \text{HRS.}$$

THICKNESS OF SLURRY = 6"

$$\text{WT.} = \frac{10{,}800 \times 33 \times .5 \times 62.4 \times .07 \times 1.10}{2000\ \text{lb/TON}}$$

= 428 TONS (BENTONITE)

WT. OF CEMENT = 10,800 X 33 X .5 X 3.33 Lbs/CF

= 593,406 Lbs

REASONABLE CONTRACT ESTIMATE WORKSHEET
(EM 1110-2 1302)

SHEET 4 OF

SUBJECT: OPTION 2 – VIBRATING BEAM CUTOFF WALL

QUANTITY: 356,400 SF

EQUIPMENT

UNIT OF EQUIPMENT	SIZE	NO.	HOURS*	RATE	AMOUNT
CRANE – MANITOWOC 3900	335 HP	1	960	122.23	$ 117,341.
LEADS	32" X 86'	1	960	12.67	12,163
VIBRATOR		1	960	40.00	38,400.
GENERATOR SET	125 KW	3	960	12.46	35,885
SILOS 10 CF	160 TON	2	960	8.07	15,494
BATCH PLANT	30 CY/HR	1	960	46.85	44,976
SLURRY MIXER W/ PUMP	1.5 CY	1	960	15.00	14,400
WATER TRUCK	5000 GAL	2	960	35.88	68,890
HOLDING TANK W/AGITATOR & TRAILER		1	960	17.59	16,886
PUMP HIGH PRESSURE	37 HP	1	960	14.81	14,218
*NOTE: USE WORKING HOURS	SUBTOTAL				$ 378,653
	SMALL TOOLS		3 % OF LABOR		13,565
	TOTAL EQUIPMENT COST				$ 392,218

LABOR

OPERATION	CRAFT	NO.	HOURS	RATE	AMOUNT
	FOREMAN	1	960	43.24	$ 41,510
CRANE	OPERATOR	1	960	42.24	40,550
	OILER	1	960	36.89	35,414
MIXER	OPERATOR	1	960	39.39	37,814
PUMP	OPERATOR	2	960	39.39	75,629.
TRUCK	DRIVER	2	960	34.81	66,835.
	LABORER	6	960	26.81	154,426
				TOTAL LABOR COST	$ 452,178

ENG FORM 1741a, Nov 81 — EDITION OF NOV 67 MAY BE USED — (Proponent: DAEN-CWE-BA)

REASONABLE CONTRACT ESTIMATE WORKSHEET
(EM 1110-2-1302)

SHEET 5 OF

SUBJECT: OPTION 2 - VIBRATING BEAM CUTOFF WALL

QUANTITY: Δ = 356,400 SF

MATERIALS

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
BENTONITE	TON	428	110.	$ 47,080.
CEMENT	CWT.	5,934	3.60	21,362.
INJECTION BEAM				10,000.
WATER				200
			TOTAL MATERIALS COST	$ 78,642.

SUPPLIES

DESCRIPTION	UNIT	QUANTITY	PRICE	AMOUNT
			TOTAL SUPPLIES COST	

SUMMARY FOR TRANSFER TO ENG FORM 1739 OR 1740

EQUIPMENT	$ 392,218
LABOR	452,178
MATERIALS	78,642.
SUPPLIES	
TOTAL	$ 923,038

REMARKS: **Prices on these items are based on quotations from manufacturers or suppliers*

DATE: 7/28/94

PREPARED BY: CTA

CHECKED BY: MOE

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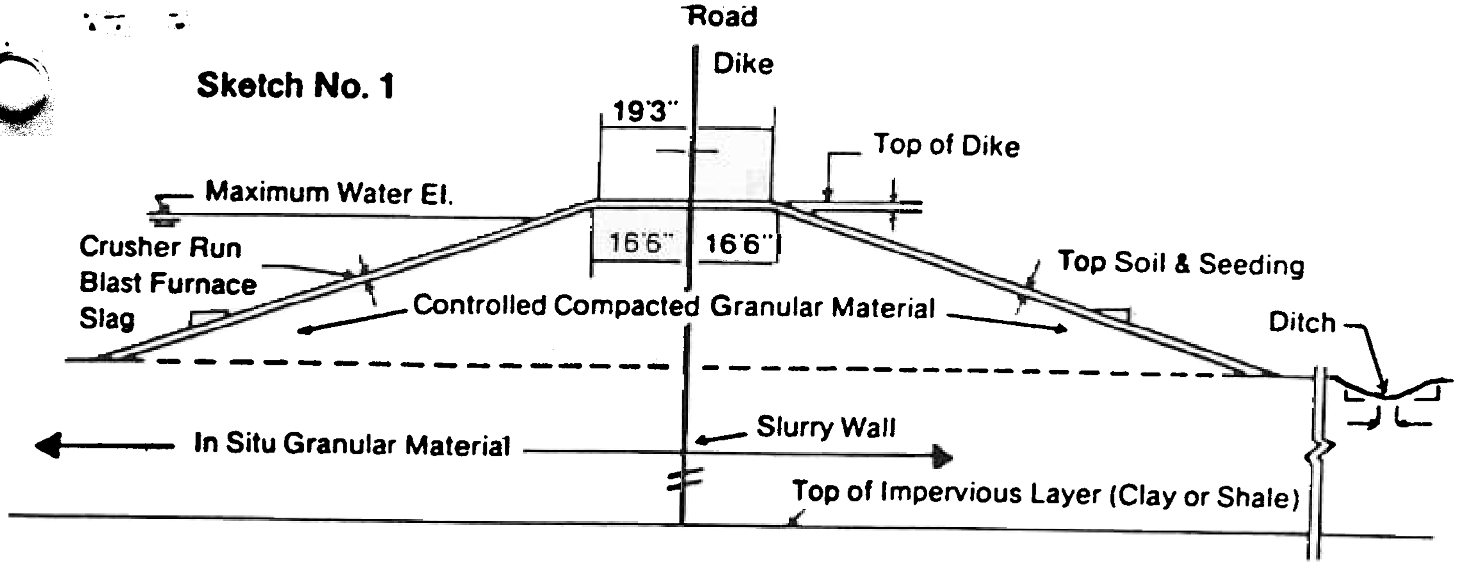
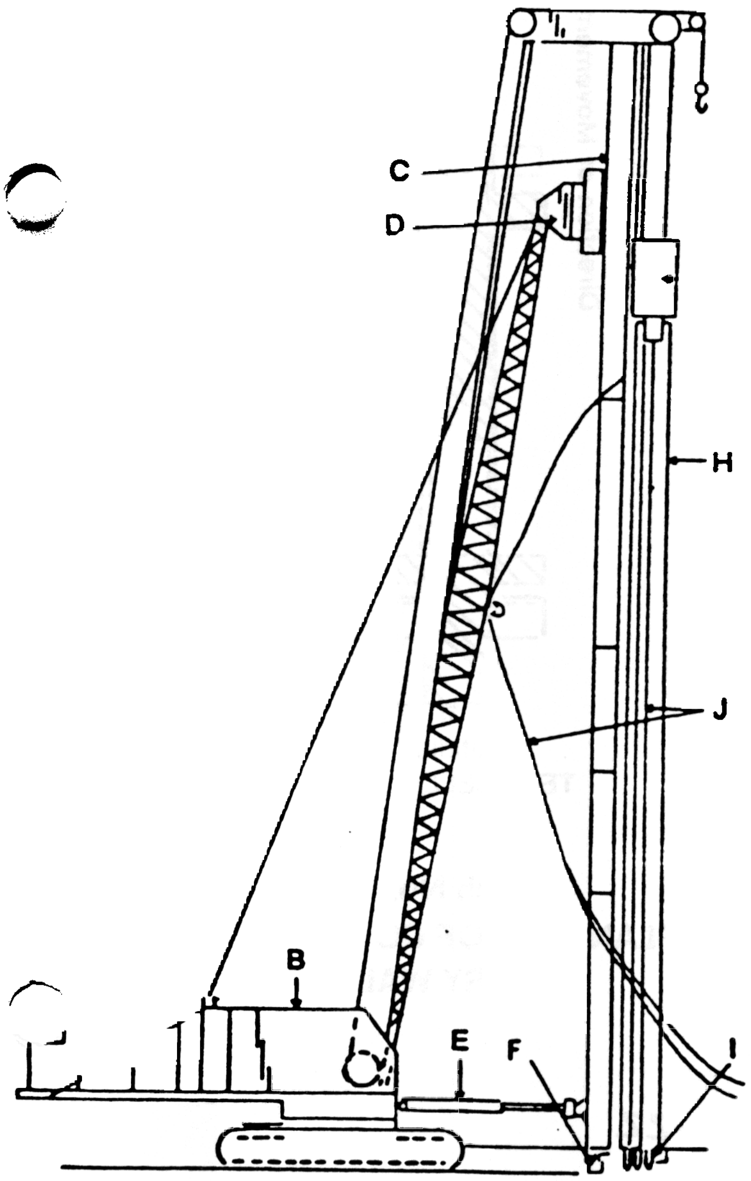
Sketch No. 1





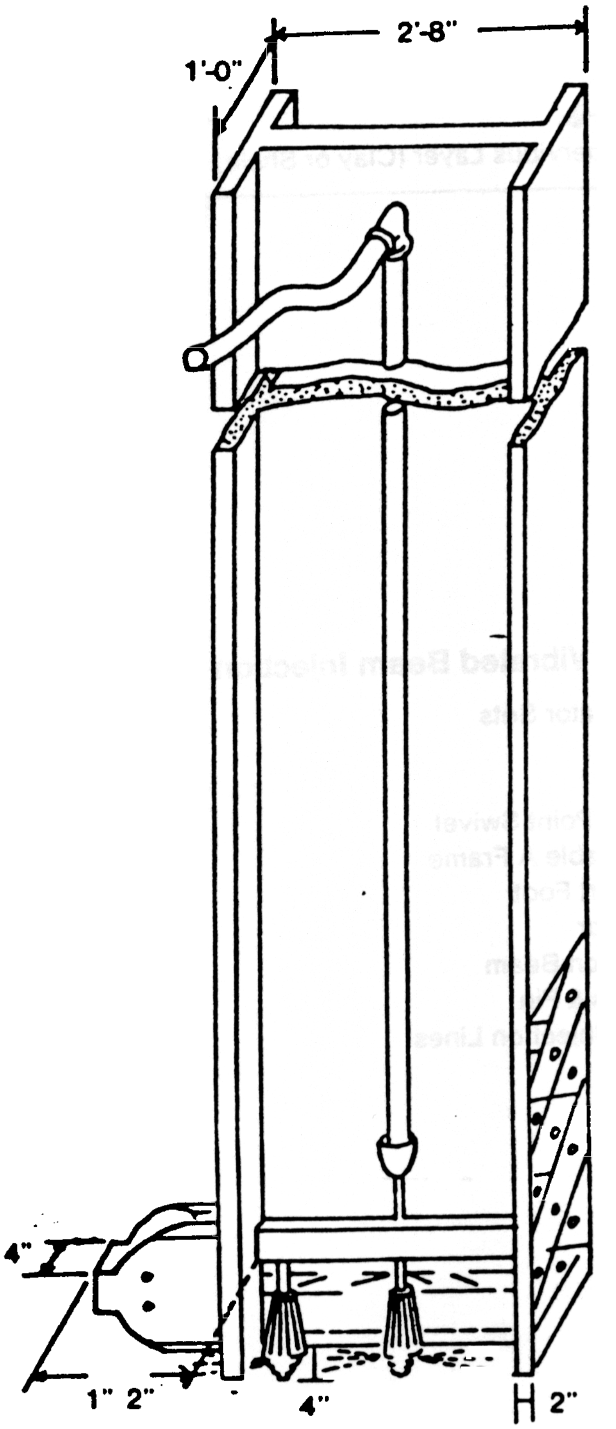
Typical Vibrated Beam Injection Set Up

A. Generator Sets
B. Crane
C. Leads
D. Boom Point Swivel
E. Adjustable A Frame
F. Support Foot
G. Vibrator
H. Injection Beam
I. Nozzles & Fin
J. Slurry Injection Lines

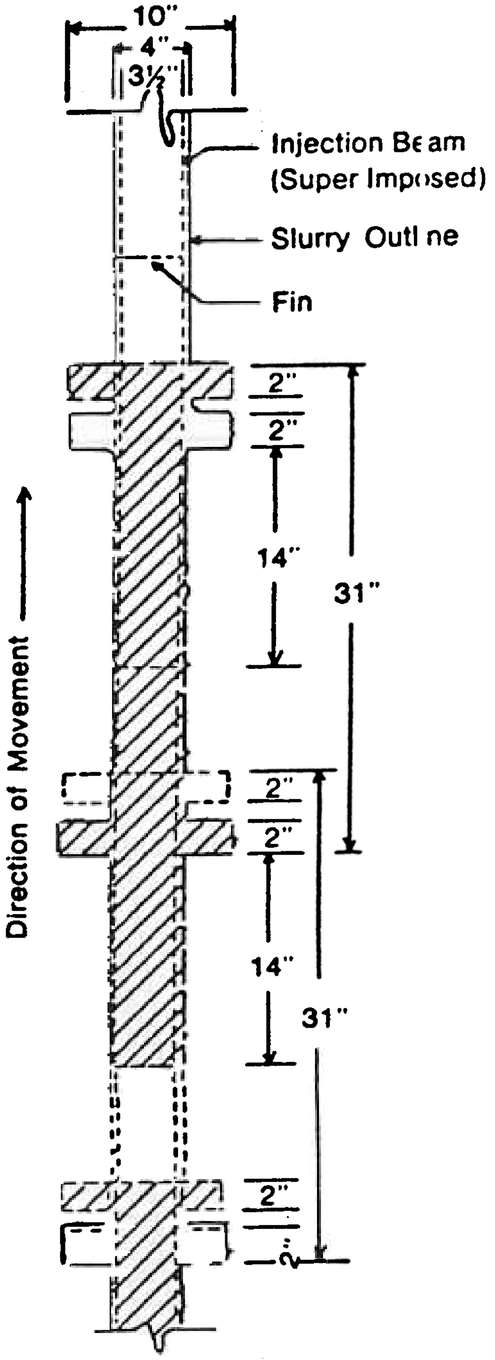
B4-21

Sketch No. 3

BEAM CONFIGURATION FOR INSTALLATION OF TEST CELL 3 SCHAHFER GENERATING STATION



DIRECTION OF MOVEMENT



Detail 2
TEST CELL NO. 3

Sketch No. 4
PLAN VIEW OF COMPLETED SLURRY WALL

B4-22

IMPERMIX SELECTED TEST RESULTS : 1990-1995

PROJECT	TEST PROGRAM	IMPERMIX	CURING (Days)	PERMEABILITY K (cm/sec.)	U.C. (psi)
RMA/Shell Oil	DNAPL Compatibility	612	28	1.0E-08	N.D.
Spec.: K=1E-7 cm/s	(Brown Associates)			9.0E-10	
Saugus LF	Water Permeability	510	30	3.0E-08	N.D.
Spec.: K=1E-7 cm/s	Water Permeability	511	30	1.7E-08	N.D.
	Water Permeability	612	30	8.2E-09	N.D.
	(Wheran Engineering)				
Fort Wayne	Water Permeability	612	180	9.1E-08	N.D.
Spec.: K=1E-7 cm/s	Leachate Compatibility	511	180	1.6E-09	177.7
	Water Permeability	511	180	2.4E-08	N.D.
	Leachate Compatibility	612	180	2.0E-09	196.9
	(Woodward Clyde)				
Niagara Falls	DNAPL Compatibility	511	28	2.4E-08	N.D.
Spec.: K=1E-7 cm/s	(Huntington Eng. & Env.)				
Deer Park	Permeability & U.C.	611	22	2.0E-07	49.3
Spec.: K=1E-6 cm/s	(Woodward Clyde)				
	In Situ/Q.A.	611	28	1.6E-07	75.6
	U. of Akron OH	611	70	6.8E-09	N.D.
	(Mc Bride & Radcliff)				
ETCo R & D	Permeability & U.C.	520 (1)	20	2.4E-07	238
	Permeability & U.C.	820	30	9.0E-09	N.D.
	Permeability & U.C.	611 (2)	180	6.0E-09	N.D.
	(Woodward Clyde)				
French site	IMPERMIX 1 (water)	612	180	3.00E-09	N.A.
	IMPERMIX 1 (DNAPL)	612	180	5.00E-10	N.A.
	IMPERMIX 2	511	180	8.00E-10	N.A.
9nth Ave. Gary IN	STS QA heat cure	612	10	5.50E-08	41
Spec.: K<1E-7 cm/sec	normal cure	612	60	3.60E-08	132

1 20% of sand by volume
2 Polymerized
3 5% of Portland. $\gamma = 69$ Lb/CF

128 Corlies Avenue. Pelham, NY 10803 Phone : (914) 738-4880 Fax : (914) 738-4804

CELRC ED-C COST ESTIMATE FOR OPTION 3 - HDPE CUTOFF WALL 15' DEEP 28 July

1. MATERIAL COST (QUOTATION FROM GSE LINING TECHNOLOGY)
= $ 1.75 / SF

2. INSTALLATION COST (QUOTATION FROM BARBELLA ENVIRONMENTAL TECHNOLOGY)
= $ 8.25 / SF

COST = $ 10.00 / SF
MARKUPS, 11% = $ 1.10
SUBTOTAL = $ 11.10
CONTINGENCIES, 20% = $ 2.22
TOTAL COST = $ 13.32 /SF